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Overcoming physiological seed dormancy in semi-arid *Prostanthera* (Labiatae)

P.J. Ainsley^{a, b} & M.K. Jones^{a, c}

^a Botanic Gardens of Adelaide, Seed Conservation Centre, North Terrace, Adelaide, South Australia 5000
Email: phillip.ainsley@sa.gov.au

^b School of Earth and Environmental Sciences, The University of Adelaide,
230 North Terrace, South Australia 5005

^c Current address: HortResearch, 120 Mt Albert Road, Auckland 1142, New Zealand

Abstract

The genus *Prostanthera* belongs to the family Labiatae, and is comprised of about 100 species endemic to Australia. With the exception of a few species that have previously been studied, the dormancy mechanism and germination requirements of the genus remain largely unknown. Seeds are characterised by the presence of a mericarp plug and have fully developed spatulate embryos. In this study, seeds from three species (*Prostanthera eurybioides*, *P. behriana* and *P. calycina*) covering both sections (*Prostanthera* and *Klanderia*) of the genus, were subjected to treatments including pulse dry heat (80°C for 10 minutes), removal of the mericarp plug and combinations of both treatments. Using these approaches, germination rates of 100% were achieved for all species tested. Contrary to earlier reports for the genus, seeds that had been stored under controlled conditions for nearly eight years were shown to be viable and could also be germinated to high levels. Results confirmed that the genus has seeds that are physiologically dormant, and that the mericarp plug plays a significant role in the germination process. Mechanisms by which seed dormancy is alleviated under natural field conditions are proposed.

Keywords: Lamiaceae, *Prostanthera*, germination, mericarp plug, seed dormancy.

Introduction

The genus *Prostanthera* Labill. belongs to the family Labiatae, and is comprised of about 100 known species, all of which are endemic to Australia (Conn 1999). The genus is divided into two sections, sect. *Prostanthera* and sect. *Klanderia* (F.Muell.) Benth., with the division primarily based on floral structure (Conn 1984). Commonly known as mint bushes, many species of *Prostanthera* are recognised in the Australian horticultural industry for their fast growth and spectacular appearance when flowering (Leigh et al. 1984).

Fruits consist of four one-seeded nutlets (mericarps) formed within a persistent calyx, with seeds dehiscing during the warmer months (Toelken 1986). Individual seeds are characterised by a prominent attachment scar that we have defined as a mericarp plug (Ainsley et al. 2008). Whilst the presence of this structure is consistent across the genus, until recently there was limited understanding about the potential role the plug structure may play in the germination process (Ainsley et al. 2008).

In a previous study, seeds of *Prostanthera eurybioides* F.Muell. were found to exhibit physiological dormancy (Ainsley et al. 2008). Contrary to previous reports for other *Prostanthera* species (Sorensen & Jusaitis 1995;

Tierney 2006), there was no evidence of seed coat related physical dormancy, and it was concluded that the mericarp plug was acting as a mechanical barrier to ensure *in situ* germination occurs when environmental conditions are conducive to maximising seedling survival. Dormancy in *P. eurybioides* was alleviated using a range of treatments including exposing seeds to gibberellic acid, micro-excision of the mericarp plug, and subjecting seeds to a pulse dry heat treatment. In contrast, the dormancy mechanism and seed ecology for many other species within the genus remains relatively unknown (Carter & Walsh 2006; NSW National Parks and Wildlife Service 2000; Tierney 2006). Knowledge about the germination requirements for other genera of Australian Labiatae appears similarly limited, with only one report for *Hemigenia exilis* (Cochrane et al. 1999) located during an extensive literature search. In that study, the authors reported that it was necessary to remove what was termed a 'seed plug' followed by a chemical treatment with gibberellic acid before seed dormancy was overcome and germination could occur (Cochrane et al. 1999). Therefore the primary objective in the current study was to determine if the germination strategy developed for *P. eurybioides* could be applied to other *Prostanthera* species, and to improve understanding about the dormancy mechanism present in a wider range of species across the genus.

Materials and Methods

Seed material

Three species of *Prostanthera* were tested in this study, two from the section *Prostanthera* (*P. eurybioides* and *P. behriana* Schltdl.) and one from the section *Klanderia* (*P. calycina* F.Muell. ex Benth.). Seeds used for experiments were harvested from wild origin field plants (Table 1). For this study, seeds were harvested between November 2004 and January 2005 depending on the species, and once brought back to the laboratory at the Botanic Gardens of Adelaide in South Australia, stored under constant controlled environmental conditions (15°C and 15% relative humidity) until experiments were commenced during August 2005. These seeds were therefore 7–9 months old when experiments started. For comparative purposes a *P. eurybioides* seedlot harvested in December 1997 that had been dried under ambient conditions, and stored hermetically in dark conditions at 5°C was also tested. These seeds were 7 years and 8 months old when experiments started. Seeds (Fig. 1) ranged in size ($2.5 \pm 0.5 \times 0.9 \pm 0.1$ mm), and had fully developed spatulate embryos (Baskin & Baskin 2007). Embryo type was determined by dissecting seeds longitudinally followed by examination under a dissecting microscope. Seedlot viability, as determined by a cut-test on a random selection of 100 seeds, was greater than 80% for all of the seedlots used.

Seed surface sterilisation

To control fungal infestation during germination testing, seeds were surface sterilised in 20% (v/v) hydrogen peroxide (Chem-Supply, Australia) for 10 minutes, then rinsed three times in sterile distilled water. Seed sterilisation was conducted after any pulse heat treatment, and prior to the removal of the mericarp plug to minimise the detrimental affect of exposing moistened seeds to high temperature, and embryos directly to the sterilising solution.

Seed Germination

Based on earlier findings (Ainsley et al. 2008) seeds were subjected to the following treatments: (i) control (no treatment), (ii) pulse dry heat treatment (80°C for 10 minutes), (iii) excision of the mericarp plug, and (iv) pulse dry heat followed by mericarp plug removal. Heat treatment was applied using pre-warmed convection ovens, with timing of the exposure period commencing once seeds were placed in the oven and the temperature had returned to 80°C. Mericarp plugs were removed by soaking seeds in water for 30 minutes and then excising the mericarp plug using a scalpel blade. Due to the small

size of seeds, mericarp plug removal was undertaken using a dissecting microscope.

Experimental design

For all treatments, four replicates of 25 seeds were used. Following any pretreatments, seeds were placed in glass Petri dishes containing dampened white silica sand overlaid with filter paper and incubated under a diurnal temperature regime of 22°C for 12 hours (under light conditions) followed by 10°C for 12 hours (under dark conditions). Light was provided by cool white fluorescent tubes. These conditions are representative of those experienced in the agricultural sector in southern Australia during autumn (Ainsley, unpublished data), and were chosen as they were found to be optimal for the germination of *P. eurybioides* (Ainsley & Ottewell 2008). To maintain moisture levels, Petri dishes were irrigated weekly with sterile distilled water. Germination, defined as radicle emergence \geq half the length of the seedcoat, was recorded weekly. Experiments were run for 12 weeks, with any non-germinated seeds cut-tested on completion to allow the germination frequency to be adjusted to reflect the actual number of filled seeds tested. Seeds were deemed viable if they were filled with a cream-white and firm endosperm.

Statistical analysis

Final germination totals (recorded at 8 weeks) were analysed for statistical significance by analysis of variance (ANOVA) using SYSTAT 12 for Windows (Systat Software Inc. 2007). To satisfy requirements of normality for statistical analysis, percentage values for germination frequency were arcsine-transformed before analysis (non-transformed data appears in Figures). Fisher's least significant difference ($P < 0.05$) was used to determine whether there were significant differences between treatment means.

Results

For both *P. eurybioides* and *P. behriana* the first evidence of germination for all treatments was observed after 7 days. Where the mericarp plug was left intact, this was characterized by either splitting or lifting of the entire plug structure by the radicle. Radicle emergence was observed 14–21 days after experiments commenced (Fig. 2). In contrast, whilst early germination was also observed for *P. calycina* in seeds where the mericarp plug had been excised, it was not until much later (day 49) that radicle emergence commenced in seeds where the mericarp plug had been left intact (Fig. 2).

Moderate levels of germination (34–52%) were achieved for all three species without the need for pretreatment (Fig. 2). Increases in germination (up

Table 1. Voucher information of seed material used.

Prostanthera eurybioides F.Muell., Mt Monster Conservation Park, S.A. (36°12.221'S, 140°19.330'E), *D.J.Duval* 53 (AD172960). — *P. behriana* Schltdl., Blackhill Conservation Park, S.A. (34°53.170'S, 138°43.077'E), *P.J.Ainsley* 85 (AD173049). — *P. calycina* F.Muell. ex Benth., Calpatanna Waterhole Conservation Park, S.A. (33°01.562'S, 134°21.676'E), *P.J.Ainsley* 87 (AD173051).

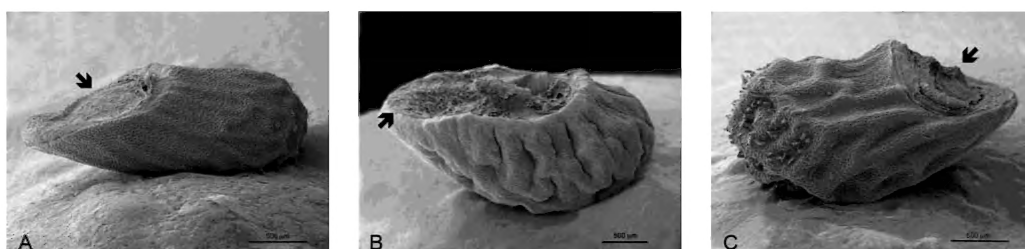


Fig. 1. Seed images. **A** *Prostanthera eurybioides*; **B** *P. calycina*; **C** *P. behriana*. Black arrow indicates locality of mericarp plug. Scale bars: 500 μ m. — Seeds were mounted directly onto pin type SEM mounts (12.6 mm diameter) with 12 mm carbon tabs. All samples were coated with gold before observation in a Phillips PSEM 505 scanning electron microscope (Philips, Eindhoven, Netherlands) at an accelerating voltage of 12kV. — **A** AD172960; **B** AD173051; **C** AD173049.

to 35.9%) and rate of radicle emergence associated with a pre-incubation pulse dry heat treatment (80°C, 10 minutes) were found to be significant ($F = 18.508$, $P = <0.001$). Removal of the mericarp plug also significantly affected germination totals ($F = 105.115$; $P = <0.001$), yielding further increases of up to 2.9-fold for all three species (Fig. 2). The highest level of germination (100%) for all three species occurred by pre-treating seeds with a pulse dry heat treatment (80°C, 10 minutes) followed by removal of the mericarp plug (Fig. 2). Whilst there was no significant difference in germination totals across the species tested ($F = 1.881$, $P = 0.145$), a significant interaction between species and the germination treatment ($F = 10.252$, $P = <0.001$) was observed. *P. eurybioides* seed that had been stored *ex situ* for nearly eight years germinated to levels similar to freshly collected seed (Fig. 2) with no significant difference in germination observed ($F = 0.085$, $P = 0.773$).

Discussion

In this study, high levels of germination (100%) were achieved for all three species of *Prostanthera* being studied. Whilst a moderate level of germination was observed without any pre-germination treatment, the use of pulse dry heat, excision of the mericarp plug or combinations of both these methods, significantly improved germination, and this is consistent with findings that we published from an earlier study (Ainsley et al. 2008). Results also show that similar germination treatments can be applied across both sections of the genus (*Prostanthera* and *Klanderia*) with similar success.

Based on these findings, we propose that non-deep physiological dormancy (Baskin & Baskin 2007) appears to be consistent across the genus and that the mericarp plug plays a significant role in controlling the germination process. Although it has been established through seed imbibition experiments that physical dormancy is not present in *Prostanthera* (Ainsley et al. 2008) the mericarp plug acts as a mechanical barrier and is involved in regulating germination. We concur with the views of Baskin and Baskin (2004), and consider

this mechanical barrier a component of physiological dormancy.

For all three species, whilst removal of the mericarp plug maximised germination response, a pulse dry heat treatment was also found to improve germinability. There are a number of potential mechanisms that explain the promotive effect of pulse heat exposures on germination rates and seed dormancy state, including loosening cells in localised regions such as the hilum, chalazal cap or strophilar plug (Keeley & Fotheringham 1998) and inducing changes to membrane structure (Hallet & Bewley 2002). Whilst it is likely that a pulse heat seed treatment in *Prostanthera* species weaken or loosen cells associated with the attachment point of the mericarp plug, it also appears that other mechanisms within or around the embryo are being affected as seen by the synergistic increase in germination level when combining mericarp plug excision with pulse heat in two of the species (*P. eurybioides* and *P. behriana*) tested in this study.

P. calycina seeds were the largest tested in this study, and are characterised by a larger mericarp plug surface area and thicker seed coat in comparison to *P. eurybioides* and *P. behriana*. These differences in part may explain why it took longer for *P. calycina* seeds with an intact mericarp plug to germinate in comparison to the other species tested. Future research should consider whether this morphological variation relates to a different thermal tolerance range and if a higher pulse temperature for a longer period proves more effective in promoting germination in this species.

The high levels of germination (97%) in eight year old *P. eurybioides* seeds tested in this study imply that this species is orthodox in its seed storage behaviour (Pritchard 2004). Assuming seeds are dried appropriately and stored under suitable conditions, *ex situ* seed storage should provide a viable conservation option. Preliminary data for other *Prostanthera* species that have been stored with reduced seed moisture content (approximately 5%) at low temperature (-20°C) for at least 12 months are yielding similar germination results (Ainsley et al., unpublished). This is in contrast to a previous report (NSW National Parks

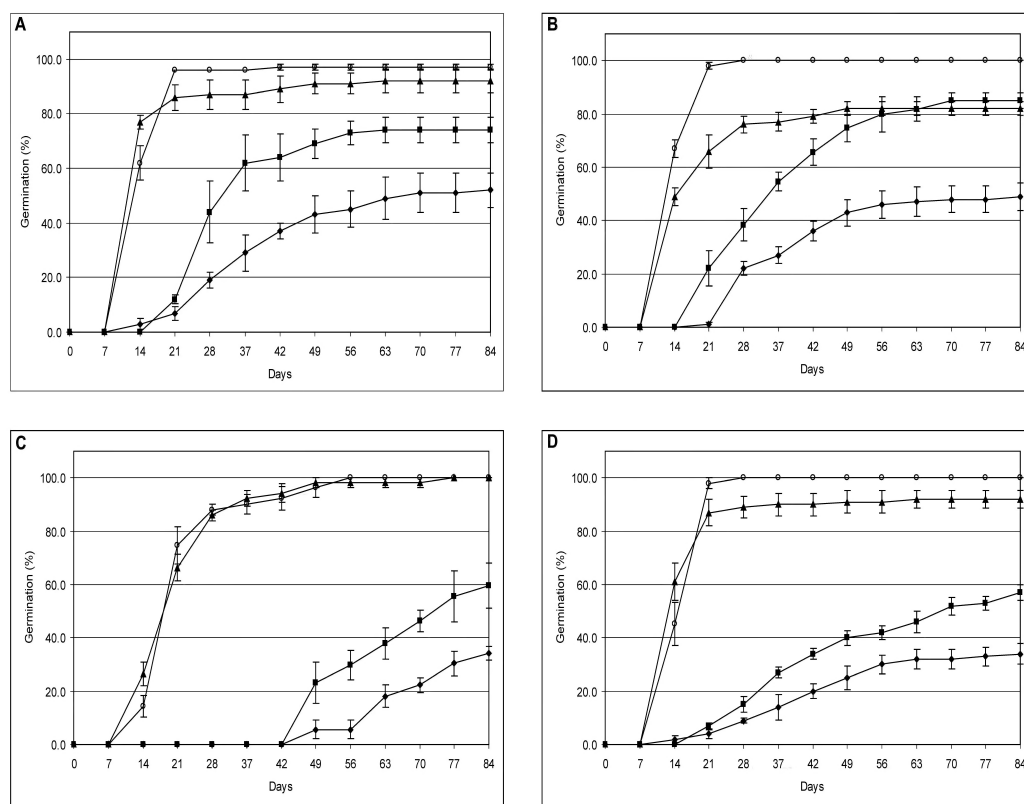


Fig. 2. Germination frequency following various pretreatments (♦ = control; ■ = pulse heat; ▲ = plug removal; ○ = pulse heat + plug removal). **A–B** *Prostanthera eurybioides*: **A** collected 1997, **B** collected 2005; **C** *P. calycina*; **D** *P. behriana*. — Four replicates of 25 seeds were used for each treatment. Seeds were incubated at 10/22°C with a 12 hour photoperiod. Seeds were 7–9 months old when experiments started and had been stored at 15% RH and 15°C. *P. eurybioides* seeds collected in 1997 were 7 years and 8 months old, and had been stored at 5°C.

and Wildlife Service 2000) for seeds of *P. junonis* B.J.Conn, which lost all viability within 12-months of collection. The most likely explanation for this contrast is the use of inappropriate storage conditions or poorly interpreted viability results from seeds prior to storage. Unfortunately storage conditions were not described for that study and it is therefore not possible to conclusively resolve this discrepancy.

A number of *Prostanthera* species are considered threatened in their natural environment (Leigh et al. 1984; Carter & Walsh 2006). It is therefore important to improve our understanding about seed ecology in the genus to assist in developing appropriate management plans for conservation significant species. The current study has confirmed that the mericarp plug is a limiting factor in the germination process, and we would like to propose mechanisms by which this could be naturally overcome in the soil seed bank. Under field conditions, surface abrasion or mericarp degradation from soil and sand particles or exposure to elevated temperatures

via heat radiation from associated rock surfaces and raised soil temperatures during summer months may assist in this process. The current study also confirms that exposing seeds to moist conditions for extended periods promotes germination in *Prostanthera*. As the three species tested in the current study are endemic to semi-arid southern Australia, which is characterised by limited natural rainfall ranging between 250 and 500 mm per annum, this may be a survival strategy, whereby seeds only germinate in wetter years when the chance of seedling survival and plant establishment is enhanced as a result of prolonged and higher soil moisture levels. There is also evidence that *Prostanthera* seeds respond positively to fire (Carter & Walsh 2006; NSW National Parks and Wildlife Service 2000), including two of the tested species (*P. eurybioides* and *P. behriana*, personal observation). Whilst the exact mode of action is not known (chemical and/or heat), elevated upper soil temperatures experienced during a fire event, which in semi-arid Australian mallee shrublands can range from

60–120°C to a depth of 5 cm depending on fire intensity (Bradstock et al. 1992; Bradstock & Auld 1995) could induce a physiological response similar to exposing seeds to pulse heat under laboratory conditions.

In Australia many native plant species have complex germination strategies (Merritt et al. 2007), and it is possible that the genus *Prostanthera* may respond to multiple dormancy breaking and germination cues as a natural adaptation to maximise opportunities for germination and enhance population survival in a highly variable natural environment where rainfall and ecological events such as fire are unpredictable and cannot be relied upon.

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A method to induce adventitious rooting in microshoot cultures of *Thryptomene ericaea* (Myrtaceae)

P.J. Ainsley^{a, b} & T.C. Lee^a

^a Seed Conservation Centre, Botanic Gardens of Adelaide, North Terrace, Adelaide, South Australia 5000

^b School of Earth and Environmental Sciences, The University of Adelaide,
230 North Terrace, South Australia 5005

Email: ainsley.phillip@saugov.sa.gov.au

Abstract

A protocol to induce a high level of root formation in microshoot cultures in the flowering shrub *Thryptomene ericaea* F.Muell. has been developed. Microshoot cultures were initiated from field grown plants and proliferated in Damiano nutrient medium supplemented with 1.0 μ M 6-benzyladenine (BA) and 1.0 μ M kinetin. Adventitious rooting was induced by culturing elongated shoots in 0.7% (w/v) water-agar supplemented with 1.0 mM indole-3-butyric acid (IBA) for 48 hours then transferring the shoots to hormone free basal medium for 8 weeks. Under these conditions, a rooting frequency of 85% was achieved. Plantlets were successfully acclimatised in soil, and subsequently developed into phenotypically normal plants.

Keywords: Myrtaceae, *Thryptomene*, root formation, cultures.

Introduction

Thryptomene ericaea F.Muell. is a showy medium sized shrub that grows in the understory of mallee vegetation and is endemic to Kangaroo Island and Eyre Peninsula in South Australia. Growing to a height of 1.2 metres, it produces sprays of flowers between September and December. Flowers include 5 stamens, 5 sepals, 5 petals and 2 ovules. Petals are ovate, white in colour and approximately 1 mm long (Green 1986). A clonal selection, Centenary Starburst™ (Scarvelis 2000), was chosen as South Australia's floral emblem for the Centenary of Federation in 2001. There has also been interest in the use of *Thryptomene ericaea* in the floral industry, as the flowering branches have long vase life and are excellent as cut flowers (Beardsell 1996). Currently, flowering stems are harvested from wild populations on Kangaroo Island, South Australia. Although the present volume of harvested material is not significant, there is potential for increasing pressures on these wild populations.

Propagation of this woody plant species has proven difficult using conventional methods, with a strike rate of less than 10% reported for woody cuttings (State Flora, South Australia, personal communication). Whilst germination of seed from *Thryptomene* species has been reported, germination has proven difficult, with seeds requiring specific pretreatments to overcome dormancy issues (Beardsell et al. 1993). Several attempts have also been made to tissue culture shoot tips of a closely related species, *Thryptomene calycina* (Lindl.) Stapf, but endogenous contaminants prevented establishment of *in vitro* shoot cultures (Beardsell 1996). To our

knowledge this is the first report describing successful root formation in microshoot cultures for the genus.

Materials & Methods

Research to develop a rooting protocol was conducted over a 12 month period between January and December 2000 at the Botanic Gardens of Adelaide (South Australia). Shoot material of *Thryptomene ericaea* was collected during spring 1999 from adult plants growing at Wittunga Botanic Garden (South Australia). Shoot material harvested outside the plants active growing season was found to be suboptimal for introduction into tissue culture due to increased levels of endogenous contamination issues (data not shown). Shoot pieces were excised in the laboratory and washed in 0.4% (v/v) Phytan 20 (a mixture of benzyl ammonium chlorides) for 2 minutes, then rinsed 3 times with sterile distilled water. The final rinse occurred overnight (12 hours) with gentle agitation. Explants, 10–15 mm in length, consisting of shoot tips and nodal segments bearing small axillary shoots were excised from the washed material. These were surface sterilised in 0.015% (w/v) mercuric chloride dissolved in 0.4% (v/v) sodium hypochlorite for 9 minutes (Rugini 1986) then rinsed 3 times with sterile distilled water. Sterilised explants were cultured in individual 30 ml polycarbonate tissue culture tubes containing 1/2-strength Damiano nutrient medium (Damiano et al. 1991) supplemented with 0.5 μ M 6-benzyladenine (BA). This nutrient medium, is based on Murashige and Skoog (1962) medium, and has been modified by lowering the total nitrogen to approximately 1/2-strength



Fig. 1. Root induction in microshoot cultures of *Thryptomene ericaea*. For root induction, explants were cultured in 0.7% (w/v) water-agar supplemented with 1.0 mM IBA for 48 hours then transferred to full-strength hormone free Damiano medium for 8 weeks. Scale bar 10 mm.

and changing the ratio of $\text{NO}_3^-:\text{NH}_4^+$ to 3:1 (Damiano et al. 1991). All media contained 3.0% (w/v) sucrose, were solidified with 0.7% (w/v) agar (SIGMA) and adjusted to pH 5.7 prior to autoclaving (121°C at a pressure of 103 kPa for 20 minutes). Explants were maintained at $25 \pm 1^\circ\text{C}$ with a 16 hour photoperiod ($40 \mu\text{mol m}^{-2} \text{s}^{-1}$) provided by Osram 36 W cool white fluorescent tubes. After 4 weeks, healthy uncontaminated explants were transferred to full-strength Damiano basal medium supplemented with 1.0 μM BA + 1.0 μM kinetin, and maintained with a monthly subculture period. Explants were subcultured at least 3 times on this medium before being used for rooting experiments.

Three rooting experiments were conducted with methods based on earlier work undertaken by the author (Ainsley et al. 2001). The first tested chronic auxin application over an 8 week period. Shoots were transferred to rooting media supplemented with indole-3-butyric acid (IBA: 0.0, 1.0, 2.5, 5.0, 10.0, 15.0 μM), α -naphthaleneacetic acid (NAA: 0.0, 1.0, 2.5, 5.0, 10.0, 15.0 μM) or combinations of both (0.5+0.5, 1.25+1.25, 2.5+2.5, 5.0+5.0, 7.5+7.5 μM). The second experiment examined the effectiveness of exposing shoots to acute auxin levels by dipping explants in different hormone solutions. Shoots were dipped for 30 seconds in either IBA (0.0, 5.0, 10.0 mM) or NAA (0.0, 5.0, 10.0 mM) that had been dissolved in 70% (v/v) ethanol, followed by a transfer to hormone free basal medium for 8 weeks. The final experiment tested a similar approach, using lower auxin concentrations for longer time periods. In this experiment, shoots were cultured in water-agar (0.7% w/v) supplemented with IBA (0.0, 0.5, 1.0 mM) or NAA (0.0, 0.5, 1.0 mM) for a range of times (24, 48, 72 hours) before being transferred to hormone free basal medium for a further 8 weeks. Full-strength Damiano medium was used for all rooting experiments. For each treatment, 20 elongating shoots (10–15 mm in length) were tested individually in 30 ml polycarbonate tissue culture tubes. Explants were cultured under dark

conditions for the first 7 days, and then transferred to light conditions (described above). On conclusion of experiments, rooting frequency was determined as a percentage of the number of explants that developed roots for each treatment. Root numbers were counted at the same time, with a standard error determined within treatments. Experiments were replicated once only.

To ensure rooted explants could be outplanted and were phenotypically normal, shoots with roots 5–10 mm in length were transferred to a glasshouse. Plantlets were removed from culture, and the roots gently washed in distilled water to remove any residual agar medium. These were planted into seedling trays containing sterilised compost (composted pine bark: washed sand: perlite: peat = 6:2:1:1) and placed inside large clear plastic bags which were sealed to maintain high humidity. Over 4 weeks, relative humidity was slowly decreased by gradually opening the plastic bags. After a further 6–8 weeks, established plants were transferred to individual 100 mm plastic pots. Plantlets were acclimatised in a glasshouse at $25 \pm 2^\circ\text{C}$ under natural daylight conditions.

Results & Discussion

IBA was the most effective auxin for the initiation of adventitious roots, with the acute auxin treatments yielding higher rooting frequencies and root numbers as compared to the chronic auxin treatments (Table 1). Although some root induction was recorded following shoot exposure to IBA or NAA at levels up to 15.0 μM for 8 weeks, the maximum rooting frequency with this approach was only 30% (Table 1). Furthermore, there appeared to be no advantage in combining the two auxins in the rooting medium. In comparison, while rooting frequencies of up to 50% (Table 1) occurred following explant dipping in concentrated auxin solutions (5.0–10.0 mM), this technique induced explant burning and high levels of shoot hyperhydricity. The most suitable approach occurred by lowering auxin concentration (0.5–1.0 mM) and extending exposure time for up to 72 hours. Using this regime, up to 95% of explants developed adventitious roots (Table 1). Optimum rooting conditions were achieved by culturing shoots on 0.7% (w/v) water-agar supplemented with 1.0 mM IBA for 48 hours then transferring shoots to hormone free basal medium for 8 weeks. Under these conditions, 85% of explants developed multiple roots that were branched and white in colour (Figure 1). Whilst a higher level of rooting occurred by pretreating shoots with 1.0 mM IBA for 72 hours (Table 1), shoot health was reduced, and was therefore not deemed optimum.

On transfer to the glasshouse, 70% of the plantlets transferred survived acclimatisation and developed into phenotypically normal plants. Flowering was observed within 3 years.

This study reports a protocol for rooting *Thryptomene ericaea* under tissue culture conditions. These techniques provide a rapid and more efficient alternative to the

Table 1. Summary of auxin treatments that induced adventitious rooting in *Thryptomene ericaea*.

Auxin	Concentration (μM)	Exposure time	Exposure method	Rooting frequency (%)*	Number of roots / explant (\pm SE)
Chronic					
IBA	15	8 wks	solid media	15	1.0 \pm 0.0
NAA	5	8 wks	solid media	30	1.0 \pm 0.0
NAA	15	8 wks	solid media	20	1.5 \pm 0.3
IBA + NAA	2.5 + 2.5	8 wks	solid media	10	1.0 \pm 0.0
IBA + NAA	5 + 5	8 wks	solid media	10	1.5 \pm 0.0
IBA + NAA	7.5 + 7.5	8 wks	solid media	15	1.0 \pm 0.0
Acute					
IBA	5000	30 s	dip treatment	10	4.0 \pm 0.0
IBA	10000	30 s	dip treatment	50	1.4 \pm 0.3
NAA	5000	30 s	dip treatment	20	1.0 \pm 0.0
NAA	10000	30 s	dip treatment	20	2.5 \pm 0.5
IBA	500	24 h	solid media	20	1.5 \pm 0.5
IBA	500	48 h	solid media	55	2.2 \pm 0.4
IBA	500	72 h	solid media	30	1.8 \pm 0.3
IBA	1000	24 h	solid media	40	2.9 \pm 0.6
IBA	1000	48 h	solid media	85	3.4 \pm 0.4
IBA	1000	72 h	solid media	95	4.8 \pm 0.4
NAA	500	24 h	solid media	10	1.0 \pm 0.0
NAA	500	72 h	solid media	5	2.0 \pm 0.0
NAA	1000	24 h	solid media	5	3.0 \pm 0.0
NAA	1000	48 h	solid media	10	1.5 \pm 0.5
NAA	1000	72 h	solid media	40	2.4 \pm 0.5

*based on 20 explants.

methods currently used to propagate this species, and provide an opportunity to produce material for plantation growing to reduce the pressure on natural stands that are currently harvested for the cut flower trade.

Many native Australian plants have proven difficult to root by both woody cuttings and in tissue culture (Johnson 1996). The technique described in this study has since been successfully used to assist with adventitious rooting in *Eucalyptus* species (Glocke et al. 2006) and may have direct application for other native Australian woody plant species where rooting is proving difficult.

Acknowledgments

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A reappraisal of *Ptilotus aristatus* and *P. blackii* (Amaranthaceae)

D.E. Albrecht^a & T.R. Lally^b

^a Northern Territory Herbarium, Department of Natural Resources, Environment, the Arts and Sport,
P.O. Box 1120, Alice Springs, Northern Territory 0871.

E-mail: dave.albrecht@nt.gov.au

^b Australian National Herbarium, Centre for Plant Biodiversity Research,
G.P.O. Box 1600, Canberra, Australian Capital Territory 2601.

E-mail: Terena.Lally@csiro.au

Abstract

The taxonomy of *Ptilotus aristatus* Benl and the related *P. blackii* Benl is revised and their relationship to one another clarified. *Ptilotus aristatus* is here treated as comprising two subspecies, *P. aristatus* subsp. *aristatus* and *P. aristatus* subsp. *micranthus* Albr. & Lally, nom. et stat. nov. *Ptilotus aristatus* var. *eichlerianus* (Benl) Benl is synonymised under *P. aristatus* subsp. *aristatus*, and *P. aristatus* var. *exilis* Benl and *P. aristatus* var. *stenophyllus* Benl are synonymised under *P. aristatus* subsp. *micranthus* Albr. & Lally. The original circumscription of *P. blackii* is shown to be a mixed concept (including *P. aristatus* subsp. *aristatus*), and this taxon is redescribed. Keys to *P. blackii* and *P. aristatus*, and to the subspecies of *P. aristatus* are provided. Distribution maps of all recognised taxa are presented.

Key word: Amaranthaceae, *Ptilotus*, taxonomy, nomenclature.

Introduction

Recent taxonomic papers by Davis (2004; 2007; 2009), Bean (2008) and Lally (2008; 2009) signify a new era in the classification of *Ptilotus* R.Br. (Amaranthaceae), which up until the mid 1990's was dominated by the complex taxonomy of Gerhard Benl. Davis' work has focused on the genus in Western Australia, while Bean has considerably improved the taxonomy of eastern Australian species, relegating many of Benl's infraspecific taxa to synonymy, and Lally has treated taxa from both Western Australia and South Australia. Preparation of a treatment of *Ptilotus* for the forthcoming new edition of *Flora of South Australia* by the second author has prompted the reassessment of the infraspecific taxa of *P. aristatus* and the related *P. blackii*. Benl (1984) recognised four varieties in *P. aristatus*, a small pink-flowered perennial herb occurring in arid regions of the Northern Territory and South Australia. In this paper we recognise only two of Benl's infraspecific taxa and treat them at subspecific rather than varietal rank. We also discuss the confusion associated with the typification of *P. blackii* and misapplication of that name to plants in South Australia and the Northern Territory.

Materials and methods

This study is based on examination of populations in the field, glasshouse grown material, and herbarium specimens or digital images from AD, CANB, DNA, MEL and PERTH. Measurements were made from fresh specimens and herbarium material (rehydrated where required).

Terminology used here to describe the hairs follows that of Benl (1971), as translated by Burbidge (1972). The hairs are basically of the same type (simple) but vary in the degree to which lateral projections are produced at the septa between the primary cells.

The leaves of the taxa described here could be interpreted as petiolate, but are here treated as sessile. The leaf lamina extends and narrows to the leaf base, with no discernible petiole. This feature is also present in other *Ptilotus* species, e.g. *P. erubescens* Schldl. and *P. seminudus* (J.M.Black) J.M.Black.

Taxonomy

Key to *Ptilotus aristatus* and *P. blackii*

1. Leaves drying dark green to blackish-green; thickened basal portion of tepals (externally, above perianth tube) forming a prominent glabrous keel; hairs on distal margin of keeled portion not distinct from those on remainder of tepal surface; Western Australia ***P. blackii***
- 1: Leaves drying pale green or yellow-green; thickened basal portion of tepals (externally, above perianth tube) convex or keeled, glabrous or hairy; distal margin of thickened portion with a skirt of hairs that are shorter and denser than those on the remainder of tepal surface; Northern Territory, South Australia ***P. aristatus***

Ptilotus aristatus Benl

Mitt. Bot. Staatssamml. München 4: 79 (1961). —
Holotype: Northern Territory: Charlotte Waters just N of the Northern Territory–South Australia border and a little east of the railway line to Alice Springs, 27 May 1939, R.A.Simpson s.n. (AD 95836091).

Perennial or facultative annual *herb* to 40 cm high with stout taproot; stems striate, with sparse to dense, subverticillate or verticillate hairs to c. 2 mm long, often glabrescent. *Leaves* sessile, with sparse subverticillate or verticillate hairs to c. 2 mm long, hairs denser on new growth and in leaf axils, often glabrescent, green, drying pale green or yellowish-green; apices acuminate or mucronate, mucro to 1.5 mm long; basal leaves spatulate, obovate or rarely narrowly obovate, 12–110 mm long including the long attenuate base which is usually equal to or longer than upper wider portion, 3–30 mm wide; cauline leaves ovate, narrowly ovate, elliptic, obovate or narrowly obovate, 7–52 mm long, 1.3–16 mm wide. *Inflorescences* hemispherical, ovoid, or rarely obovoid or subcylindrical spikes, finally 12–60 mm long, 9–35 mm wide, up to 80-flowered. *Bract* 3.5–8.5 mm long including aristate apex to 3 mm long, with moderate to dense, nodose, subverticillate or verticillate hairs over external surface, hyaline or chartaceous, brown all over or midrib and apex only; *bracteoles* 4–8 mm long, including aristate apex to 3 mm long, with moderate to dense, subverticillate or verticillate hairs mostly confined to the midrib externally, hyaline, midrib brown. *Perianth* 7.5–17 mm long including a basal tube 1–2 mm long, pink to pinkish-purple. *Tepals* linear, concave, outer tepals 0.5–2.3 mm longer than inner, apical portion scarious, glabrous, apex erose, obtuse or truncate; outer surface of basal tube with dense, nodose, subverticillate or verticillate hairs to 1 mm long; outer tepal surface with a thickened basal portion immediately above the tube, convex and glabrous, or keeled and with very short simple or verticillate hairs to 0.2 mm long, or rarely glabrescent, the distal margin of the thickened basal portion with dense, subverticillate hairs to 4 mm long, forming an erect skirt, remainder of outer tepal surface (excluding glabrous apical portion) with sparse to moderately dense, nodose or subverticillate hairs to 5 mm long, shorter near apex and on tepal margins adjacent to thickened basal portion, with sparse to dense verticillate hairs to 0.8 mm long beneath; outer tepals glabrous inside; inner tepals with sparse to moderately dense crisped nodose hairs inside, attached to the margins near base, hairs extending to a quarter of tepal length. Fertile *stamens* 2 (rarely 3), filaments 2.5–6.5 mm long, dilated basally; *staminodes* 3, filaments often shorter than fertile stamens, dilated basally; *staminal cup* minute to indeterminable; *anthers* of fertile stamens 0.5–1.3 mm long, usually exerted to side of perianth at anthesis. *Ovary* stipitate, with sparse, nodose hairs adjacent to style, sometimes on both sides, rarely glabrous; *style* eccentric, 1.6–4 mm long, straight or sinuate.

Notes. *Ptilotus aristatus* is morphologically similar to *P. blackii*; see under the latter species for further discussion. Two subspecies are recognised.

Key to subspecies

1. Perianth > 10 mm long; longest hairs on outer tepals (2.5–) 3–5 mm long; bracts and bracteoles 5–8.5 mm long; style 3–4 mm long *P. aristatus* subsp. *aristatus*
1. Perianth 7.5–10 mm long; longest hairs on outer tepals to 2 (–2.5) mm long; bracts and bracteoles 3.5–5 mm long; style 1.6–2.2 mm long . . . *P. aristatus* subsp. *micranthus*

Ptilotus aristatus Benl subsp. *aristatus*

Ptilotus aristatus Benl var. *aristatus*, J. Adelaide Bot. Gard. 1: 204 (1979).

Ptilotus eichlerianus Benl, Mitt. Bot. Staatssamml. München 7: 310 (1970). — *P. aristatus* var. *eichlerianus* (Benl) Benl & H. Eichler, Muelleria 5: 259 (1984). — **Holotype:** South Australia: c. 14 km north of Eringa Homestead (Eringa Homestead is c. 155 km NNW of Oodnadatta), 11 Sept. 1966, *E.A. Shaw* 490 (M n.v.). **Isotype:** AD 96642224.

Ptilotus blackii auct. non Benl: Benl, J. Adelaide Bot. Gard. 1: 204 (1979), pro parte; Benl in Jessop (ed.), Fl. Cent. Austral. 81 (1981), pro parte; Benl in Jessop & Toelken (eds), Fl. S. Austral. ed. 4, 1: 324 (1986), pro parte.

Illustration. G. Benl, Trans. Roy. Soc. South Australia 88: 54, fig. 1 (1964), as *Ptilotus blackii*.

Basal leaves 12–110 mm long including long attenuate base, 4–25 mm wide; cauline leaves 10–52 mm long, 2–14 mm wide. *Inflorescences* 10–60 mm long, 20–35 mm wide. *Bract* 5–8.5 mm long, some with brownish coloration extending beyond midvein; *bracteoles* 6–8 mm long. *Perianth* (10–) 12–17.5 mm long; outer tepals longer than inner by 1–2.3 mm, the outer surface with hairs to 5 mm long, thickened basal portion convex and glabrous, distal margin of thickened portion with hairs 2–4 mm long. Fertile *staminal* filaments 4–6.5 mm long; *style* (3–) 3.2–4 mm long.

Distribution and habitat. *Ptilotus aristatus* subsp. *aristatus* occurs in the Northern Territory near the South Australian border and extends into South Australia as far south as Evelyn Downs station (Fig. 1). Most collections have been made in the Stony Plains bioregion with a few records coming from adjacent areas within the Finke and Simpson-Strzelecki Dunefields bioregions. This subspecies typically occurs in open vegetation on gibber plains or slopes with loam- or clay-textured soils (rarely with sandy surface veneer), sometimes extending into adjacent floodouts. *Badman* 5887 (AD) was apparently collected from a sandplain, which is considered an atypical habitat for the subspecies.

Notes. As defined here, *P. aristatus* subsp. *aristatus* includes specimens previously referred to *P. aristatus* var. *aristatus* and *P. aristatus* var. *eichlerianus*, and specimens from South Australia and the Northern Territory (but not Western Australia) previously referred to *P. blackii*. The principal numeric characters used by Benl to distinguish *P. aristatus* var. *aristatus* and *P. aristatus* var. *eichlerianus*, i.e. inflorescence width and perianth length, are unreliable due to continuous variation. Furthermore, inflorescence shape appears to be strongly influenced by developmental stage. In

reducing *P. eichlerianus* to *P. aristatus* var. *eichlerianus* Benl (1984) himself acknowledged intermediate forms between it and var. *aristatus*.

Ptilotus aristatus subsp. *aristatus* differs from subsp. *micranthus* by its longer perianths, bracts, bracteoles and styles. It also has a glabrous, convex, thickened basal portion on the outer tepals, whereas in subsp. *micranthus* the thickened basal portion is usually hairy and keeled.

Conservation status. Placing *P. aristatus* var. *aristatus* and var. *eichlerianus* in synonymy under *P. aristatus* subsp. *aristatus* does not impact on the conservation status of the taxon in the Northern Territory. The Near Threatened coding (sensu IUCN 2001) for the varieties (Albrecht et al. 2007) under the *Territory Parks and Wildlife Conservation Act 2000* is also appropriate for *P. aristatus* subsp. *aristatus*. In South Australia, however, where *P. aristatus* var. *aristatus* is given Rare status and *P. aristatus* var. *eichlerianus* Vulnerable status (National Parks and Wildlife Council 2003), Rare would seem to be the appropriate code in South Australia for the redefined *P. aristatus* subsp. *aristatus*.

Selected specimens examined

NORTHERN TERRITORY. Mt Grundy, 12 Nov. 1993, D.E. Albrecht 5654 (AD, DNA, NT); Eastern boundary of Finke River flood plain, near western boundary of Simpson Desert, 24 Apr. 1977, G.C. Cornwall 316 (AD); Mt Wilyunpa, 20 Aug. 1992, H. Coulson 39 & P.K. Latz (NT); c. 3.5 km from NT-SA border on Finke-Mt Dare Rd, 4 Sept. 1997, P. Horsfall 409 (NT); Andado Stn, 18 Apr. 1977, P.K. Latz 6852 (AD, CANB, MEL, NT, PERTH); 2 km SE of 10 mile Dam, New Crown Station, 3 Feb. 1983, P.K. Latz 9443 (NT); Andado Stn, 16 Aug. 1974, A.S. Mitchell 101 (CANB, NT).

SOUTH AUSTRALIA. Abminga Creek, 14 May 2001, R. Bates 58592A (AD, CANB); Pedirka, c. 65 km S of NT border on railway to Alice Springs, 29 Aug. 1932, E.H. Ising 2966 (AD); 12 km W of Dalhousie Springs, 29 Aug. 2004, P.K. Latz 20362 (MEL, NT); c. 10 km N of Hamilton Homestead, 8 Sept. 1987, G. Leach 1404 (AD, NSW, NT); 1 mile [1.6 km] S of Mt Sarah, c. 60 km NNW of Oodnadatta, 8 Aug. 1963, T.R.N. Lothian 1388 (AD, NT); Headwaters of Arrabunda Creek, 23 Sept. 1974, D.E. Symon 9235 (AD, CANB, NT); Dalhousie – near Oodnadatta, 21 July 1921, S.A. White s.n. (AD).

Ptilotus aristatus subsp. *micranthus* Albr. & Lally, nom. et stat. nov.

Based on: *Ptilotus aristatus* var. *exilis* Benl, Muelleria 5(4): 258 (1984). — **Holotype:** Northern Territory: 54 miles [86.4 km] NW of Alice Springs, 3 May 1962, G. Chippendale 8799 (M n.v.). **Isotypes:** AD 96349063, CANB 126984, DNA A8799, NSW n.v.

Ptilotus aristatus var. *stenophyllus* Benl, J. Adelaide Bot. Gard. 1: 204 (1979). — **Holotype:** Northern Territory: Mt Hay, Milton Park, 23 Oct. 1974, G. Griffin s.n. (CANB 254681). **Isotype:** DNA A43463.

Illustration. W. Dobbie & C. O'Malley, Centralian Land Management Association and Threatened Species Network, Alice Springs. Colour photos 1–6 (2000).

Basal leaves 12–95 (–110) mm long including long attenuate base, 3–25 (–30) mm wide; cauline leaves

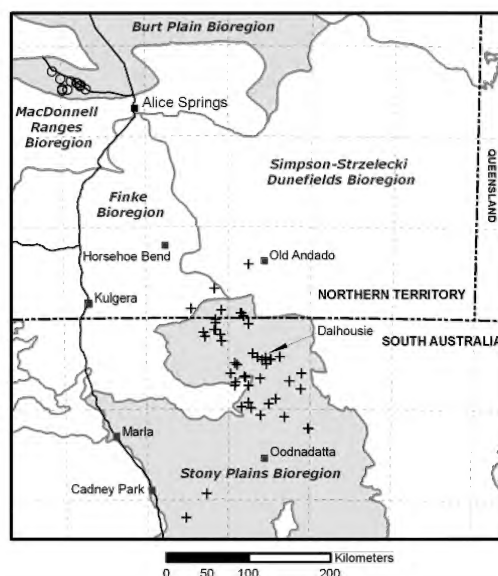


Fig. 1. Distribution of *Ptilotus aristatus* subsp. *aristatus* (cross) and *Ptilotus aristatus* subsp. *micranthus* (open circle).

9–50 mm long, 1.3–16 mm wide. **Inflorescences** 10–36 (–50) mm long, 9–22 mm wide. **Bract** 3.5–5 mm long, with brownish coloration confined to midvein; **bracteoles** 3.5–5 mm long. **Perianth** 7.5–10 mm long; outer tepals longer than inner by 0.5–1 mm, the outer surface with hairs to 2 (–2.5) mm long, thickened basal portion keeled, hairy or rarely glabrescent, distal margin of thickened portion with hairs 1–1.7 mm long. Fertile **staminal** filaments 2.5–4 mm long; **style** 1.6–2.2 mm long.

Distribution and habitat. *Ptilotus aristatus* subsp. *micranthus* is endemic to the Northern Territory where it is restricted to a relatively small area within the Burt Plain bioregion about 100 km WNW of Alice Springs (Fig. 1). It has a patchy distribution over approximately 65 km² of cracking clay plain, principally on Amburla station, with a small proportion on Hamilton Downs station (Dobbie & O'Malley 2000). Populations occur within the Undippra land system (Perry et al. 1962), characterised by red coarse structured clay soils (sometimes with surface gravel) supporting grassland dominated by *Astrebula pectinata*, *Eragrostis xerophila* and *E. setifolia*.

Notes. Leaf width appears to be the primary character on which Benl (1984) based his separation of *P. aristatus* var. *stenophyllus* and var. *exilis*. Field observations have shown leaf width to be a highly variable character, with ranges of 4–27 mm being recorded for flowering plants in several populations. Furthermore, cultivated plants exhibit variation in leaf width that appears to be

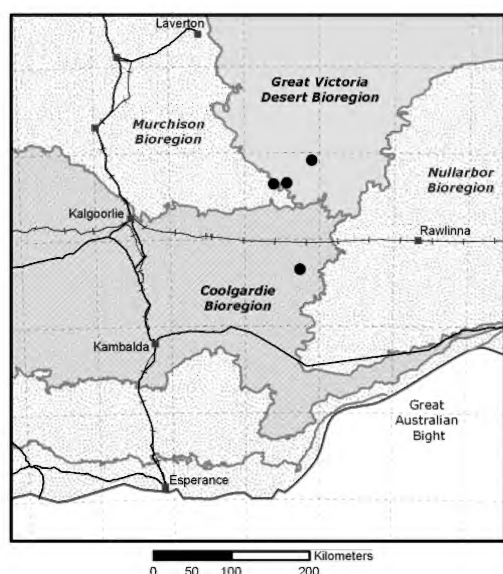


Fig. 2. Distribution of *Ptilotus blackii* (closed circle).

correlated with plant age. Young plants have broader early basal leaves that wither and disappear as plants age. Given the observed continuous variation in leaf width and absence of floral differences between the two varieties, their separation is considered untenable. They are here combined under the new epithet subsp. *micranthus*. We have recognised the taxon at subspecies rank given the significant morphological distinctions and geographical separation from *P. aristatus* subsp. *aristatus*.

The new epithet “*micranthus*” is preferred over Benl’s earlier names, as it better conveys the distinguishing features of this taxon. We have chosen to base the new name on *P. aristatus* var. *exilis*, as the type material of that name is more representative and complete, as basal leaves are included.

An aberrant collection (Collins 124) from east of Amburla Creek is considered unusual in having exceptionally large inflorescences to 110 mm long and 25 mm wide, with widely spaced flowers basally, longer tepals (to 11.5 mm long) and a longer style (to 2.6 mm long). Glasshouse grown plants from a seed voucher of this collection were typical for *P. aristatus* subsp. *micranthus*.

Seeds sown in a glasshouse at the Alice Springs Desert Park in July 2008 flowered within three months of germination. Plants in the field flower and fruit at any time of the year in response to adequate rainfall.

Ptilotus aristatus subsp. *micranthus* is easily distinguished from subsp. *aristatus* by its shorter perianths, bracts, bracteoles, stamens and styles. It also has a usually hairy, keeled, thickened basal portion

on the tepals, and shorter (to 2 (–2.5) mm long) hairs on the remainder of the tepal (to 5 mm long in subsp. *aristatus*).

Conservation status. Placing *P. aristatus* var. *stenophyllus* and var. *exilis* in synonymy under *P. aristatus* subsp. *micranthus* does not impact on the conservation status of the taxon. The Near Threatened coding (sensu IUCN 2001) for the varieties (Albrecht *et al.* 2007) under the *Territory Parks and Wildlife Conservation Act 2000* is also appropriate for *P. aristatus* subsp. *micranthus*.

Etymology. The Greek epithet *micranthus* refers to its smaller flowers (perianths).

Selected specimens examined

NORTHERN TERRITORY. 7 km W of Mt Hay trig, 10 June 2000, D.E. Albrecht 9545 (NT); Amburla Creek, W of Alice Springs, 23 Feb. 1978, G. Benl 48, J. Maconochie & L. Ulyatt (CANB, M); 3 km E of Amburla Creek, Tanami Road, 19 Mar. 2002, T.L. Collins 124 (NT); c. 67 km W of Stuart Highway on road to Yuendumu, 27 Feb. 1991, H. Coulson & L. Todd s.n. (NT); c. 5 km S of Amburla Homestead, between Valley Bore and Mt Hay Bore, 31 Aug. 2006, I.D. Fox 4054 (NT); Tanami Highway, 57.6 km W of Stuart Hwy, 25 Apr. 1988, G. Leach 1851 & M.J. Barritt (CANB, NT); Milton Park, 12 Dec. 1973, C. Lendon s.n. (NT); 95 km NW of Alice Springs, Tanami Hwy, 29 Mar. 1993, D.J. Nelson 2867 (NT); 14 km NW of Hamilton Downs Homestead, CSIRO enclosure plot, 10 Mar. 1997, M. White 51 (NT).

Ptilotus blackii Benl

Trans. & Proc. Roy. Soc. S. Australia 88: 53 (1964). —

Holotype: Western Australia: Great Victoria Desert, W.A.; Camp 57 – c. 220 km east-north-east of Kalgoorlie, c. 260 km north-east of Lake Lefroy, 20 Sept. 1891, R. Helms s.n. (AD 96216157). **Isotypes:** AD 96215164, MEL 2217620 n.v. (digital image at CANB), MEL 2217621 n.v. (digital image at CANB).

Perennial or facultative annual *herb* to 30 cm high with taproot; stems striate, glabrous or with scattered verticillate hairs to c. 0.6 mm long (denser on younger growth). *Leaves* sessile, with sparse subverticillate or verticillate hairs to c. 1.2 mm long, hairs denser on new growth and in leaf axils, usually glabrescent, green, drying dark green or blackish-green; apices obtuse or acute, ± mucronate, when present mucro to 1.2 mm long; basal leaves obovate or rarely narrowly obovate, 50–70 mm long including the long attenuate base which is usually equal to or longer than upper wider portion, 5–12 mm wide; cauline leaves narrowly ovate, obovate or elliptic 10–33 mm long, 2.2–8 mm wide. *Inflorescences* ovoid or ± hemispherical spikes, finally 12–20 mm long, 10–25 mm wide, up to 25-flowered. *Bract* 7.3–9.5 mm long including aristate apex to 2 mm long, with sparse to moderately dense, subverticillate hairs over external surface, hyaline or chartaceous, brown all over or midrib and apex only; *bracteoles* 7.8–9 mm long, including aristate apex to 2.5 mm long, with moderately dense, subverticillate hairs mostly confined to the midrib externally, hyaline, midrib brown. *Perianth* 11–14 mm long including a basal tube 1–1.5 mm long,

pink or purple. *Tepals* linear, concave, strongly keeled at base above tube, outer tepals 0.7–1 mm longer than inner, apical portion scarious, glabrous, apex erose, obtuse or acute; outer surface of basal tube with dense, subverticillate or verticillate hairs to 0.7 mm long; keeled portion above tube glabrous, remainder of outer tepal surface (excluding glabrous apical portion) with sparse to moderately dense, nodose or subverticillate hairs to 6 mm long, shortening near apex, with sparse to dense verticillate hairs to 0.8 mm long beneath, and along margins of basal keeled portion; outer tepals glabrous inside; inner tepals with moderately dense wavy nodose hairs inside, attached to the margins near base, hairs extending to a third of tepal length. Fertile *stamens* 2, filaments 4.5–6.5 mm long, dilated basally; *staminodes* 3, filaments slightly shorter than fertile stamens, dilated basally; *staminal cup* minute to indeterminate; *anthers* of fertile stamens 0.5–1.2 mm long, sometimes exerted to side of perianth at anthesis. *Ovary* stipitate, with sparse, verticillate hairs adjacent to style, sometimes on both sides; *style* eccentric, 3–4.1 mm long, straight.

Distribution and habitat. *Ptilotus blackii* is endemic to arid Western Australia, where it is currently known from a few localities near the south western edge of the Great Victoria Desert bioregion and a single location in the Coolgardie bioregion (Fig. 2). It occurs approximately 200 km east of Kalgoorlie, north and south of the trans-Australia railway line. It is recorded as growing in brown clayey sand or orange sand on flat plains in association with mallee woodland over spinifex.

Notes. Benl (1964) chose a Helms collection from Western Australia as the holotype of *P. blackii*. However, as noted by Benl, this material is immature, and therefore Benl also included a number of paratypes (representing mature plants) from South Australia to supplement his description of *P. blackii*. Unfortunately, the paratypes do not represent *P. blackii* s. str., and are referable to *P. aristatus* subsp. *aristatus*. Benl's description therefore encompasses elements of both *P. blackii* and (mostly) *P. aristatus* subsp. *aristatus*. Despite the immature nature of the holotype material, this collection is distinguishable from related species (see below) on vegetative characters, and mature collections matching the holotype are known from the same geographical area in Western Australia. The comprehensive description provided here is based on all known collections of *P. blackii*.

The correct application of the name *P. blackii* has been problematic for some time, mainly as a result of Benl's mixed concept of the taxon. Benl variously determined specimens of *P. aristatus* s.l. from the Northern Territory and South Australia as either *P. aristatus* or *P. blackii*, although the basis for this distinction remains unclear. *Ptilotus blackii* is similar to *P. aristatus* subsp. *aristatus*, particularly with respect to habit, and the indumentum, colour and apex of the bracts and bracteoles. However, it differs in its glabrous mature stems (young stems may have some scattered hairs), leaves which dry dark green

or blackish-green and the uniform hairs on the tepals. *Ptilotus blackii* also frequently has divaricate branchlets towards the top of the plant, shorter, narrower leaves, shorter inflorescences, shorter perianths and slightly larger bracts and bracteoles than *P. aristatus* subsp. *aristatus*.

Ptilotus blackii may also be confused with *P. nobilis* subsp. *nobilis*, the distribution of which overlaps that of *P. blackii*. However, *P. nobilis* subsp. *nobilis* is easily distinguished by its taller, more robust habit, basal leaves without long attenuate bases, cauline leaves usually with crenate, undulate margins, usually cylindrical inflorescences that are much longer and wider, and its longer perianths (15–44 mm long).

Conservation status. With its more restricted circumscription and few collections, *P. blackii* has recently been listed as Priority Three under the Department of Environment and Conservation (DEC) Conservation Codes for Western Australian Flora (Smith 2010). It is known to occur in the Queen Victoria Spring Nature Reserve, but requires further survey to determine its overall distribution and abundance.

Specimens examined

WESTERN AUSTRALIA. c. 127 km N of Balladonia along Zanthus-Balladonia road, R.Davis 10596, 23 Sept. 2003 (PERTH); Track from transline, 72.4 km N of Plumridge Lake, R.Davis 10605, 24 Sept. 2003 (NT, PERTH); 7 km SW of Nippon Junction, Queen Victoria Springs Nature Reserve, D.J.Pearson 92, 26 Nov. 1986 (PERTH).

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The *Thelymitra pauciflora* R.Br. complex (Orchidaceae) in South Australia with the description of seven new taxa

Robert J. Bates

38 Portmarnock St, Fairview Park, South Australia 5126

Email: bobbates63@hotmail.com

Abstract

The South Australian members of the complex of self-pollinated, mostly blue flowered, sun-orchids related to *Thelymitra pauciflora* R.Br. are discussed. There are at least twenty South Australian species in the complex, many of which were only recently published. In addition, seven species are here described as new, namely *T. crenulata* R.J.Bates, *T. hygrophila* R.J.Bates, *Thelymitra latifolia* R.J.Bates, *T. odora* R.J.Bates, *T. orientalis* R.J.Bates, *T. pallidifructus* R.J.Bates and *T. rubricaulis* R.J.Bates.

Keywords: Orchidaceae, *Thelymitra*, sun-orchids, taxonomy, new species, South Australia.

Introduction

Thelymitra J.R.Forst. & G.Forst. is a large and complex orchid genus of almost a hundred species, several described natural hybrids and a number of undescribed taxa. It is widespread in all temperate areas of Australia except true deserts. There are also a few tropical taxa in eastern Australia, about twenty species in New Zealand and at least one species each in Indonesia, New Guinea, New Caledonia and the Philippines.

About half the species of *Thelymitra* belong to a super-complex of taxa based around *T. longifolia* J.R.Forst. & G.Forst. of New Zealand (Jeanes 2004). These species are distinguished by mostly blue to mauve flowers, which are neither spotted nor strongly striped and have their column adorned with a simple tubular hood (post-anther lobe) with a pair of lateral lobes at the base. These lobes terminate in a mop- or toothbrush-like tuft of white or variously coloured cilia.

For simplicity, the Australian species of the *T. longifolia* super-complex are separated, following Jeanes (2004) into the *T. nuda* R.Br. complex of large flowered, usually fragrant, outcrossing species with coherent pollinia and the *T. pauciflora* R.Br. complex with small flowered, self-pollinated, usually un-perfumed species with non-coherent, mealy pollinia. Only the latter complex is treated in detail in this paper. The two complexes are most likely artificial (Jeanes 2004, citing unpublished results by M.A. Clements).

Jeanes (2004: 20) defined species belonging to the *T. pauciflora* complex as having

small flowers (perianth segments usually to 10 mm long, sometimes as long as 12 mm and rarely reaching or exceeding 15 mm) that are usually unscented, generally autogamous and often also cleistogamous.

The self-pollinated or autogamous nature of flowers in this complex has been discussed by Bates (1999), Jeanes (2004) and Jones et al (2010).

Self-pollination in all species of the complex is achieved through the friable, mealy or powdery pollinia falling onto the stigma directly below, usually while the flowers are still in bud. In cool weather, flowers may remain tightly closed throughout the flowering season and are therefore cleistogamous.

Autogamy is facultative, as flowers may open fully on hot days and native bees, on chance visits, transfer pollen. Hybrids have been recorded for many of the species treated here, usually with other more outcrossing species such as *T. ixioideis* Sw. or *T. nuda* R.Br. as the second parent (Jones et al. 2010; pers. obs.), but none have been recorded between species within the *T. pauciflora* complex.

Robert Brown (1810) was the first botanist to study the *T. pauciflora* complex in any detail, naming *T. pauciflora*, *T. nuda* and *T. angustifolia* R.Br.

Bentham (1873) subsumed most members of the complex worldwide under the name *T. longifolia*, but most subsequent botanists believed that there were several to many species involved (Fitzgerald 1875–95; Nicholls 1969; Clements 1989; Bates & Weber 1990; Jeanes & Backhouse 2001; Jones & Clements 1998a, 1998b).

Some of these workers merely illustrated forms which they believed to represent different species, e.g. Bates (1999) dealing with South Australian taxa. Others actually named taxa, e.g. Jones & Clements (1998a, b) described *T. fragrans* D.L.Jones & M.A.Clem., *T. malvina* M.A.Clem., D.L.Jones & Molloy, *T. granitora* D.L.Jones & M.A.Clem., *T. gregaria* D.L.Jones & M.A.Clem., *T. imbricata* D.L.Jones & M.A.Clem.; Jeanes (2000) described *T. atronitida* Jeanes and *T. planicola* Jeanes. Apart from *T. malvina* these species are not found in South Australia; none were recognised as occurring here by the above authors. It was not until Jeanes' (2004) major revision of the Australian members

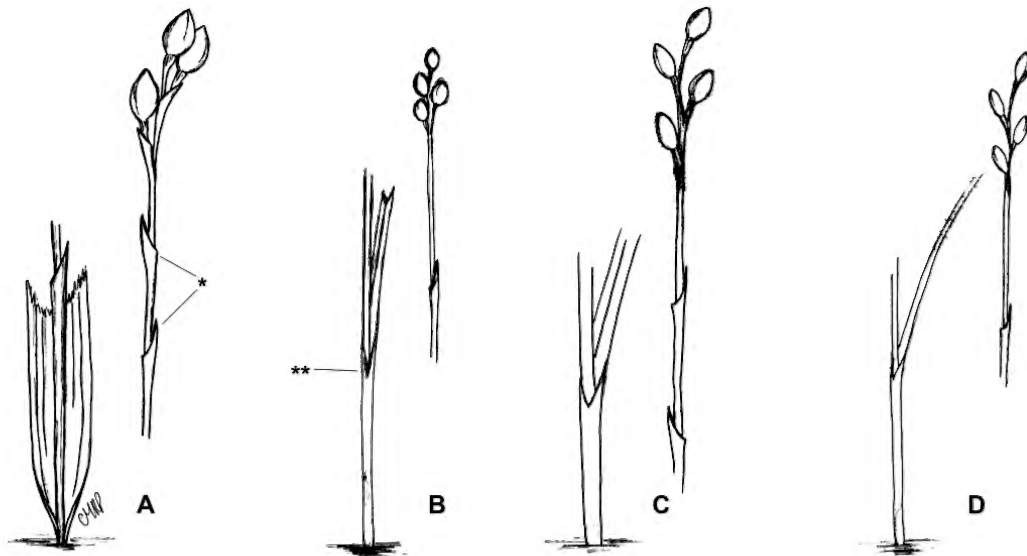


Fig. 1. Habit of species of the *Thelymitra pauciflora* complex with unopened flowers. **A** *T. latifolia*, showing the wide leaf of the plant, not sheathing the stem; **B** *T. crenulata*, with leaf sheathing the stem; **C** *T. hygrophila*; **D** *T. odora*. * bracts on the scape; ** fistula.

of the *T. pauciflora* complex that South Australian material was given any serious consideration.

Jeanes (2004) named fifteen new species from within the complex. Eight of those he recognised occur in South Australia, namely *T. albiflora* Jeanes, *T. batesii* Jeanes, *T. bracteata* J.Z. Weber ex Jeanes, *T. brevifolia* Jeanes, *T. cyanapicata* Jeanes, *T. exigua* Jeanes, *T. inflata* Jeanes and *T. peniculata* Jeanes. He also resurrected a species, which other workers had not (or only tentatively) recognised, namely *T. arenaria* Lindl.

Since 2004 another species, *T. lucida* Jeanes, previously known only from Victoria, has been added to the South Australian list (Bates 2006) resulting in 15 species in the complex for South Australia.

J.A. Jeanes suggested there may be more South Australian species for the following reasons.

Firstly, in addition to examining herbarium material Jeanes also made excursions to sun-orchid rich parts of each state looking at plants *in situ*. Unfortunately his brief visit to South Australia in 2002 coincided with a severe drought, and he did not include the South-east region in his travels despite it being rich in members of the complex (J.A. Jeanes, pers. comm., 2005). He therefore missed many of the taxa that are mostly restricted to South Australia.

Secondly, Jeanes (2004) suggested that one species, *T. peniculata* Jeanes, was highly variable throughout its range occupying habitats ranging from coastal swamps to woodland to rock outcrops inland. He predicted that it was likely to include more taxa.

Furthermore Jeanes (2004: 28) stated in his discussion under *T. pauciflora* that the species “remains

poorly-known today due to the presence of many taxa that bear several features in common with the type, but may also differ from it in subtle ways.” He then listed major features of *T. pauciflora* *sensu stricto* such as “usually with two sterile bracts”. However most of the South Australian material determined by Jeanes as *T. pauciflora* consistently has a single sterile bract.

Seven new species of the *T. pauciflora* complex in South Australia are described and named in this paper. Further work is required to resolve the limits of several other putative taxa.

There are also references to several related but undescribed species by manuscript name (i.e. ‘*T. adorata*’ Jeanes ms and ‘*T. alpicola*’ Jeanes ms), but these do not occur in South Australia (Bell et al. 2005; Jeanes & Backhouse 2006; Jones 2006, 2008).

Defining the species

All of the species named in this paper are well marked, reasonably constant entities, often forming pure populations. They reappear in similar habitat over a wide area and wherever they are sympatric with other members of the complex do not, or rarely, show any introgression. Most are allopatric, but wherever they are sympatric, hybrids are generally lacking.

Hybrids do, however, occur between members of the complex and species outside the complex, particularly with outcrossing taxa, usually as sporadic individuals of vegetatively reproducing clumps or colonies. Some of these hybrids have been named, e.g. *T. ×truncata* R.S.Rogers, a name that is generally applied to crosses between members of the *T. pauciflora* complex and plants of the blue spotted outcrossing *T. ixioides* Sm. or

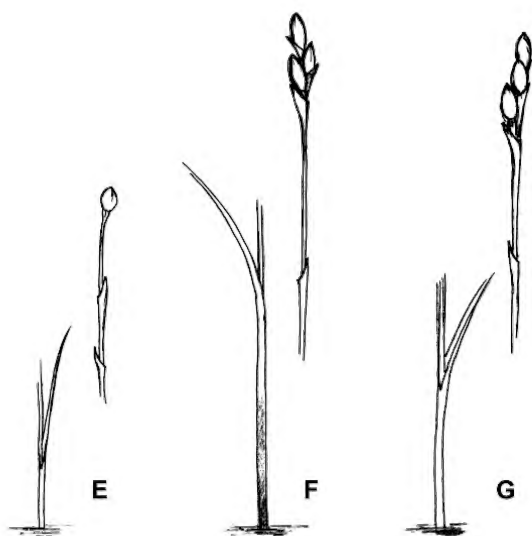


Fig. 1 (contd). Habit of species of the *Thelymitra pauciflora* complex. E *T. orientalis*; F *T. pallidifructus*; G *T. rubricaulis*.

its autogamous equivalent, *T. juncifolia* Lindl. (Jones 2006). These crosses are easily recognised as they have flower morphology similar to members of the *T. pauciflora* complex but with the darker spots of *T. ixioides* or *T. juncifolia*.

However, not much is known about crosses between different species within the *T. pauciflora* complex, as these are difficult to recognise. Jeanes (2004) points to difficulties caused to correct identification by a propensity for hybridisation.

Separating the new species: notes on morphology

Since about 1990 the author has made detailed studies of the complex in South Australia. About seven undescribed taxa were identified by 1992 and as many as ten by 2004. Following Jeanes' 2004 paper, in which most of these were named and described, the author, with the assistance of members from the Native Orchid Society of South Australia (NOSSA) began a detailed study of the genus in South Australia, matching taxa to specific habitats and different flowering times, fragrances, etc. Characters studied include vegetative features hardly considered before, such as distance from soil level to the leaf fistula (Fig. 1**); number, size and shape of sterile bracts; presence or absence of fragrance and particularly flower-bud colour (or colour of sepal exterior surface) as these were realised to be important in separating taxa.

Features used to discern taxa therefore include some not previously given much importance, as well as those, primarily of the column, defined and illustrated in Weber & Bates (1986: 2134, Fig. 998) and somewhat modified by Jeanes (2004).

The following characters have been used to distinguish species:

- *Habit*: plant robust or slender, plant height, clumping or not clumping, stem rigid or lax.
- *Leaf characters*: the degree to which the leaf base sheaths the inflorescence; leaf length, rigid or lax, ribbed or not, flat or canaliculate, with or without a glaucous bloom and with a green or red base.
- *Scape*: red or green, straight or flexuose, glaucous or not.
- *Sterile bracts*: size, shape, number and position on the scape (Fig. 1*).
- *Floral bracts*: colour, size, texture, shape and degree of sheathing. Many of these features are more important than floral features because they are more easily observed when flowers remain closed, which is the case most of the time.
- *Flower*: colour and the length of the ovary compared to flower size are two features given more importance than previously. Bud colour ranges from pale grey, green, through pink and brown to almost black. The shape and length of the floral segments, together with their colour (blue to mauve or white) are important and the number and intensity of darker striations on the segments may be useful — although this feature has not been used in the key. Within the floral column, post-anther lobe features proved to be very important, including shape, colour and texture of the orifice (Fig. 2**) as well as size, colour, shape, position, texture and angle of the column arms and their trichomes. Jones (2004) distinguished between mop- or toothbrush-like tufts of hairs at the end of the column arms (Fig. 2*, 3*).

Habitat

Many species, but not all, proved to be highly habitat specific with some restricted to peat bogs (e.g. *T. rubricaulis*), others to vernal waterholes and ponds (e.g. *T. lucida* and *T. hygrophila*), to rock outcrops (e.g. *T. frenchii* Jeanes) or even confined to laterite (e.g. *Thelymitra* sp. *Laterite* (R. Bates 63950) Bates 2007). Many of these habitat specific taxa remain to be described.

Phenology

Flowering of many species of *T. pauciflora* complex is highly dependent on good spring rainfall (e.g. *T. holmesii* Nicholls). Fire plays an important role for other unrelated species of *Thelymitra* (e.g. *T. rubra* Fitzg.). The wet spring of 2005 (Bureau of Meteorology 2005) provided one of the best flowering seasons seen since 1992, except on inland fringes, and was most productive. The drought year of 2006 proved disastrous for sun-orchids and 2007 and 2008 were little better. In these dry years, flowers either did not form, or were soon aborted (pers. obs.).

Fortunately sun-orchids of the *T. pauciflora* complex produce copious seed and often quite large populations will establish in suitable disturbed habitat, such as

regularly slashed firebreaks, especially after wet years. Occurrence of species in firebreaks is most likely not related to fire, but just to the disturbed habitat. There is no indication in any of the species below that fire does play a part in their recruitment.

Collecting specimens of the *Thelymitra pauciflora* complex

The *T. pauciflora* complex in South Australia is poorly represented in herbaria. The flowers are self-pollinated and rarely open and therefore do not attract the attention of collectors. Even wide-open flowers, once picked, quickly close and must be pressed immediately.

In the past collectors tended to see these taxa as a single variable species or they ignored them. In recent times, as collectors have become more discerning of morphological features, this has changed.

Jeanes (2004) emphasised the importance of collecting flowers and leaf portions for pickling in alcohol so that the shape and size of the flowers is preserved.

It is best to collect several flowers at different stages of development as there is always some variation and any single flower may be atypical and give a biased interpretation. Because colour and shape may be lost in dried or pickled flowers photographs are important to show colour and shape of live flowers.

When collecting from a population of plants with unopened flowers it is very easy to accidentally include material of other similar species. A proportion of collections may well, therefore, contain material of other, similar, sympatric species. It is therefore most important to collect voucher specimens for any research undertaken in this area.

It is not feasible to collect plants from the wild for *ex situ* studies as sun-orchids rarely thrive in cultivation.

Despite these difficulties between 10 and 15 taxa not recognised by Jeanes (2004) have been collected in South Australia since 2003, some apparently for the first time. Others were previously represented in the State Herbarium of South Australia by poor, fragmented material, often mixed on sheets with other species.

For those species not growing near firebreaks and requiring fire or other disturbance to initiate flowering, collections have been few and limited in number of specimens.

Consequently only the best known, often widely distributed and constant species are named and described in this paper. Other putative new taxa will continue to be investigated.

Terminology

The terminology used is that of Jeanes (2004) with some minor adjustments.

The point on the tubular leaf base through which the inflorescence emerges is called the *leaf fistula* (Fig. 1**) and its height above the leaf base is an important feature in separating species (cf. 'leaf sheathing' in the key). Likewise *bud colour* or colour of sepal exterior,

is often referred to in the key and descriptions as this is remarkably constant for most species.

Sterile bracts are the bracts on the scape other than those subtending flowers (Fig. 1*) and the number of these tends to be constant for each species. Jeanes (2004) often stated "sterile bracts 1–2", but in the author's experience for a species with a single sterile bract this number is constant, except in abnormally large specimens or in specimens suspected of exhibiting hybrid influence.

The perianth segments of *Thelymitra* species have a varying number of *darker coloured linear striations* and the number and distinctiveness of these can be significant in determining species.

Materials and methods

The strategies used were similar to those of Jeanes (2004), but with more emphasis on well pressed material and digital images since the latter allows texture and colour to be retained and gives a more holistic view. Spirit collections were made of all new taxa from as many populations as needed.

It was hardly possible to discern new species for the first time using poor material either dried or in spirit. This was only achieved by a great deal of field work, looking at large, thriving populations, especially where these were sympatric with other species for comparison. The basic technique for studying a suspected new taxon was to search as many locations with suitable habitat as possible over as wide range as the expected flowering time. This is difficult in the over-cleared and modified landscapes of South Australia.

As constant populations with the same features and flowering times began to show in the same habitats over a wide area, collections were made, GPS data was recorded and photographs taken.

Many of the species were first found at a single location, but when similar habitat was searched in different regions, these taxa were often observed to be frequent over a surprisingly wide distribution.

Some taxa that are restricted to a highly specific habitat, such as peat bogs, have so far only been seen in the South-east (SE) of the state. Although suitable habitat may once have been present in other regions, such as the Southern Lofty region (SL) or on Kangaroo Island (KI), such habitats have now been largely destroyed or massively altered.

All available herbarium material at AD and MEL was seen. Most of this had been annotated by Jeanes. No material at MEL could be assigned to any of the new taxa with certainty. The absence of old specimens in herbaria might also be explained by the fact that flowers of species of the *T. pauciflora* complex often remain closed and were therefore not collected, as collectors assumed that they were still in bud.

Key to the species of the *Thelymitra pauciflora* complex in Australia

Characters defining the T. pauciflora complex: Orchids with small (less than 2 cm across), blue, mauve or white flowers, without spots, tardily opening, with the post-anther lobe adorned with lateral lobes bearing hairlike tufts of variously coloured trichomes.

This key is modified from that of Jeanes (2004). Note that south-eastern (SE) Australia includes here South Australia and Tasmania.

1. Post-anther lobe with a glaucous or glistening bloom
 2. Post-anther lobe narrow at base and widening toward top; trichomes on the lateral lobes sparse, often connate at the base, 0.05–0.1 mm wide, bright yellow, strongly embracing the post-anther lobe
 3. Plants usually 12–30 cm tall; flowers usually 3–6, perianth segments > 10 mm long, ovate-lanceolate; post-anther lobe with much sparkling bloom, the two apical halves < 1 mm apart at their widest; trichomes of the lateral lobes adpressed outside the post-anther lobe, not inserted into the orifice and often exceeding it in height; predominantly SW Australia *T. mucida* Fitzg.
 - 3: Plants always < 12 cm tall; flower usually solitary, sometimes two; perianth segments < 10 mm long, shortly ovate; post-anther lobe with a sparse silvery bloom, the two apical halves > 1 mm apart at their widest; trichomes of the lateral lobes at least partly inserted into the orifice of the post-anther lobe and not exceeding it in height; S.A., Vic. 5. *T. orientalis*
 - 2: Post-anther lobe widest near the middle and narrowing only slightly above and below; trichomes on the lateral lobes dense, not connate at the base < 0.05 mm wide, pale or creamy yellow, not embracing the post-anther lobe
 4. Post-anther lobe very inflated, brown grading into yellow at the apex, covered in a thick, waxy bloom, deeply bilobed, the lobes 1.5–2.5 mm long, c. 1 mm wide; trichomes on the lateral lobes 1.2–1.6 mm long, usually cream or yellow; plants from dry to moist woodland habitats; flowering season late Sep. to early Nov.; predominantly S.A. (Southern Lofty region); Vic. *T. inflata* Jeanes
 - 4: Post-anther lobe somewhat inflated, mostly black with a yellow apex, with a thin, sparkling bloom, bilobed, the lobes 1.2–1.6 mm long, c. 0.6 mm wide; trichomes on the lateral lobes 1–1.2 mm long, usually white, sometimes cream; plants from swampy habitats, often standing in water at anthesis; flowering season mid-Oct. to mid-Dec.; S.A., Vic. *T. lucida* Jeanes
- 1: Post-anther lobe without any bloom
 5. Trichomes on the lateral lobes usually cream or yellow, proximal trichomes often red, at least basally
 6. Post-anther lobe very inflated, mostly brown grading into yellow at the apex, deeply bilobed, the lobes ± parallel, 1.5–2.5 mm long; S.A., Vic., Tas. *T. inflata* Jeanes
 - 6: Post-anther lobe semi-inflated, mostly black with a distinct yellow apex, bilobed, the lobes usually diverging, 0.8–1.5 mm long
 7. Perianth segments usually 8–11 mm long; trichomes on the lateral lobes 1.2–1.8 mm long, rather sparse and of an untidy appearance; flowering season mostly Nov. and Dec.; SE Australia *T. holmesii* Nicholls
 - 7: Perianth segments usually 12–15 mm long; trichomes on the lateral lobes 1–1.5 mm long, very dense and of a neat appearance; flowering season mostly late Sep. and Oct.; SW Australia *T. xanthotricha* Jeanes
 - 5: Trichomes on the lateral lobes usually white, rarely pink to mauve, proximal trichomes not red
 8. Post-anther lobe more or less erect, not curved forward; plant usually < 14 cm tall; flowers 1–3; lower sterile bract entire or deeply bifid; rock outcrops in W.A. *T. frenchii* Jeanes
 - 8: Post-anther lobe curved forward for up to 90°; plant usually > 14 cm tall; flowers often > 3; lower sterile bract entire
 9. Post-anther lobe semi-cylindric, widely open on the ventral side; sterile bracts 3–4, lower ones often leaf-like; E Australia *T. planicola* Jeanes
 - 9: Post-anther lobe not semi-cylindric, sterile bracts usually 1–3, none of them leaf-like
 10. Leaf lanceolate, usually less than half height of inflorescence (often much less than half), blade more or less flat, thin-textured, often with red margins, veins and suffusions, even wholly red; post-anther lobe often deeply and irregularly slit at the apex, usually red, orange-red or red-brown; SE Australia *T. brevifolia* Jeanes
 - 10: Leaf linear to linear-lanceolate, usually greater than half the height of the inflorescence, often fleshy and canaliculate; post-anther lobe often notched, but not irregularly slit, usually brown to black with a yellow apex
 11. Post-anther lobe strongly compressed dorsally in the distal half; apical orifice small; trichomes purple or white
 12. Post-anther lobe mostly glossy black; trichomes white; sterile bracts usually two, flowers pale blue; Vic., S N.S.W., ?S.A. *T. atronitida* Jeanes
 - 12: Post-anther lobe reddish-brown; trichomes usually purple or mauve, rarely white; sterile bracts usually 3; flowers slate-blue to purple; E and SE Australia, New Zealand *T. malvina* M.A.Clem., D.L.Jones & Molloy
 - 11: Post-anther lobe not strongly compressed; trichomes white or cream
 13. Lateral lobes not glabrous at the base, with trichomes extending more or less along their entire length in a toothbrush-like arrangement

14. Perianth segments often > 12 mm long; mature plants tall and stout; flowers > 8, (at least on many plants)
15. Post-anther lobe deeply notched, black with a yellow apex; flowers white or very pale blue; sterile bract usually solitary; near-coastal Vic. only *T. pallidiflora* Jeanes
- 15: Post-anther lobe emarginate, red-brown with a yellow apex; flowers usually blue or mauve; sterile bracts usually two
16. Lower pedicels often partially decurrent on rachis; sepals mostly green on exterior surface; base of upper sterile bract often only half encircling the scape; sterile bracts to 15 cm long; fertile bracts to 3.5 cm long; SE Australia, mostly in S.A. *T. bracteata* J.Z. Weber ex Jeanes
- 16: Pedicels never decurrent on rachis; sepals mostly purplish on exterior surface; upper sterile bract usually scape encircling, to 5 cm long; sterile bracts to 8 cm long; fertile bracts to 2 cm long; SE Australia *T. arenaria* Lindl.
- 14: Perianth segments rarely > 12 mm long; mature plants rather small and slender; flowers rarely more than 8 even on mature plants
17. Post-anther lobe narrowest at the base and broadest toward the apex, deeply notched; SW Australia *T. vulgaris* Jeanes
- 17: Post-anther lobe usually broadest near the middle, narrowing only slightly above and below, emarginate to shallowly notched; south-eastern Australia
18. Plants short and stout, to 12 cm tall, often forming clumps by vegetative reproduction; leaf nearly as long as, or longer than inflorescence; lowest fertile bract often with proximal margins connate
19. Leaf very thick, fleshy, brittle, and at least as long as inflorescence; S Vic. *T. basaltica* Jeanes
- 19: Leaf moderately fleshy, flexible, and shorter than inflorescence; SE Australia *T. exigua* Jeanes
- 18: Plants slender, not clump-forming; usually > 12 cm tall; leaf much shorter than inflorescence; fertile bracts with margins entirely free
20. Flowers 1–10, usually white; post-anther lobe reddish brown with a yellow apex; trichomes on lateral lobes in elongate tufts; S.A. *T. albiflora* Jeanes
- 20: Flowers 1–5, usually blue; post-anther lobe entirely dark blue to magenta; trichomes on lateral lobes in sub-globose tufts; S.A. (Southern Lofty region) *T. cyanapicata* Jeanes
- 13: Lateral lobes glabrous in at least the basal quarter to half, with trichomes in a more or less, terminal mop-like arrangement
21. Leaf blade flat, scape emerging at soil level; flowers lilac; post-anther lobe not inflated; S.A., ?Vic. 3. *T. latifolia*
- 21: Leaf blade at least partly channelled, often fleshy; scape emerging well above soil level; flowers blue; post-anther lobe inflated
22. Perianth segments reflexing strongly back toward the ovary at temperatures above 25°; post-anther lobe black to greenish-black throughout; coastal Vic. *T. reflexa* Jeanes
- 22: Perianth segments not or hardly reflexing; post-anther lobe never wholly black or greenish-black
23. Leaf 3/4 of the height of the inflorescence or longer
24. Plant with an overall pale greenish appearance; leaf fleshy; sterile bracts usually two; post-anther lobe shallowly notched at the apex; flowering season late Oct. to early Dec.; near-coastal Tas. *T. viridis* Jeanes
- 24: Plant without an overall pale greenish appearance; leaf thin-textured; sterile bracts usually 3; post-anther lobe usually deeply bilobed at apex; flowering season June to Oct.; Qld, N N.S.W. *T. angustifolia* Jeanes
- 23: Leaf less than 3/4 of the height of the inflorescence
25. Flowers with some degree of outcrossing, perianth segments > 12 mm long; trichomes of lateral lobes often with cream to pale yellow apices; grassy woodland plants usually growing in vernal pools; S.A. (Southern Lofty region) 2. *T. hygrophila*
- 25: Flowers hardly outcrossing, perianth segments < 12 mm long; trichomes of lateral lobes always white; woodland or heath-land plants rarely growing in vernal pools
26. Flowers fragrant, exterior surface of the buds and sepals slate grey; post-anther lobe black; S.A. 4. *T. odora*
- 26: Flowers not fragrant, exterior surface of the buds and sepals not slate-grey; post-anther lobe not black
27. Scape, bracts and sometimes ovary red to deep purple-red; trichomes on lateral lobes in elongate tufts
28. Post-anther lobe hardly crenulate in its apical portion, the apex with a cleft > 1 mm deep, the orifice > 0.5 mm across; trichomes of the lateral lobes not obscuring the orifice of the post-anther lobe; S.A. (South-east, only N of Mt Gambier) 7. *T. rubricaulis*
- 28: Post-anther lobe distinctly crenulate in its apical portion, the apex with a cleft < 1 mm deep, the orifice < 0.5 mm across; trichomes of the lateral lobes usually at least partly obscuring the orifice of the post-anther lobe; S.A. (South-east) 1. *T. crenulata*

- 27: Scape, bracts and ovary not red to deep purple-red; trichomes on lateral lobes in sub-globose tufts
- 29: Sterile bract always single; ovary very pale, yellow-green; exterior surface of sepals lilac with pale edges; S.A. 6. *T. pallidifructus*
- 29: Sterile bracts usually 2; ovary not very pale, yellow-green, exterior surface of sepals not lilac with pale edges
- 30: Flowers usually 1–3, most often pale blue; lateral lobes 0.5–1 mm long, bent sharply upwards at c. 90° near the middle; post-anther lobe entire or emarginate; E and SE Australia *T. pauciflora* R.Br.
- 30: Flowers usually 4–10, most often mauve or deep purplish blue; lateral lobes 1.2–1.5 mm long, curved gently upwards; post-anther lobe usually deeply bilobed at the apex
- 31: Plants of dry hills; leaf usually < 10 mm wide; mature flower buds inflated, about 10 mm in diameter, subacute at apex; exterior of sepals pink with darker striations; post-anther lobe orifice widely gaping, the two apical halves often compressed; trichomes of lateral lobes often sparse or lacking; S.A. (S Flinders Ra. and Mount Lofty Ra.) *T. batesii* Jeanes
- 31: Plants mostly of damp habitats, particularly swamp margins in South Australian forms; leaf usually > 10 mm wide; mature flower buds not inflated, < 8 mm in diameter, acute at apex; exterior of sepals ranging from brown to grey and pale-edged; post-anther lobe orifice hardly gaping, the two apical halves not compressed; trichomes of the lateral lobes dense; SE Australia *T. peniculata* Jeanes

Taxonomy

New species of South Australian *Thelymitra*

1. *Thelymitra crenulata* R.J.Bates, sp. nov.

A Thelymitra pauciflora R.Br. *una bractea sterili, floribus saturatiore cyanellis alabastris fuscioribus, columna parva cyanea cum lobo post-anthera crenulato incisurato minuto saepe partim obtectae trichomatibus complanatis, florenti postea, et crescendo plerumque in turbario differt.*

Typus: South Australia, South-East region: Kangaroo Flat (Native) Forest Reserve, south of Glencoe, common on break KF 18 adjacent KF 15 on firebreaks in peaty sand-heathland near waterholes, 12 Nov. 2003, R.Bates 61622; holo: AD; iso: MEL.

Thelymitra sp. *Black buds* (R.Bates 64389) Bates, J. Adelaide Bot. Gard. Suppl. 1: 202 (2005).

Thelymitra sp. *Dark buds* (R.Bates 64416) Bates, Orchids S. Austral., ver. 1, CD-ROM (2006).

Thelymitra crenulata (R.Bates 64389) Bates, Orchids S. Austral., ver. 4, CD-ROM (2009), nom. inval.

Illustration: Bates (2006–2010), as *Thelymitra* sp. *Dark buds* (R.Bates 64416) and *Thelymitra crenulata* (R.Bates 64389).

Glabrous terrestrial orchid to 30 cm tall. *Tubers* ovoid 20–25 mm long, 8–15 mm wide. *Leaf* linear, 6–20 cm long, 1–3 mm wide, erect, fleshy, canaliculate, ribbed abaxially, green with a purplish base or wholly purplish, sheathing the scape for 2–6 cm, apex acute. *Scape* 15–30 cm long, 0.8–2 mm diam, straight, red to purplish and green. *Sterile bract* single, ovate, set below the middle of the scape, 2–3 cm long, closely sheathing, red to purplish and green, apex acute. *Fertile bracts* ovate, 6–15 mm long, 3–4 mm wide, sheathing the pedicels, purplish-red, with some pale bloom, acute. *Pedicels* 3–6 mm long, slender. *Ovary* green, narrow obovoid, 4–8 mm long, 3–4 mm wide. *Flowers* 1–7; 10–12 mm diam, deep blue with 8–10, strong, linear,

darker lines, opening widely only on warm to hot humid days and usually only briefly; *buds* dark purple to brown with lilac sepal margins. *Perianth segments* 6–7 mm long, 4–5 mm wide, concave, acute or apiculate; *dorsal sepal* ovate often hooding the column, apiculate; *lateral sepals* ovate, apiculate; *petals* ovate obtuse to subacute, *labellum* ovate subacute, smaller than the sepals. *Column* erect from the end of ovary, 3.5–4 mm long, 2–2.5 mm wide, oblong, blue; *post-anther lobe* hooding the anther, 1.5–2 mm long, tubular, not inflated, curved sharply forward before the middle, narrower and ribbed toward the apex, dark or reddish-brown, apex small, yellow, margins irregular, crenulate, not thickened, with a tiny opening; *auxiliary lobes* tiny, quadrate or absent; *lateral lobes* convergent, 0.8–1 mm long, digitiform, porrect, curved sharply upwards, each with an elongated, mop-like arrangement of white trichomes addressed to the apex of the post-anther lobe, individual trichomes to 0.8 mm long with thickened ends. *Anther* inserted about midway along the column, 2–2.1 mm long, c. 1 mm wide, connective produced into an apical beak; *pollinarium* 1.5–1.7 mm long, *viscidium* more or less circular, *pollinia* friable, mealy, white, soon collapsing onto the stigma. *Stigma* situated at base of column, ovate-quadrate, 1.6–1.7 mm long, margins irregular. *Capsules* obovoid, 8–10 mm long, 4–5 mm wide, erect, ribbed. **Fig. 1B, 3A–C.**

Distribution and habitat. Apparently endemic to South Australia in a small area of the lower south-east around Mount Gambier (SE), but possibly also in adjacent parts of south-western Victoria. The species is restricted to disturbed areas such as slashed firebreaks and tracks on damp sandy heath near waterholes.

Conservation status. Rare and localised, threatened by changed hydrology and management practices such as

ploughing firebreaks or allowing old tracks to grow over, probably **endangered** according to NPWC (2003).

Flowering period. Late October to mid November; like most members of the complex the flowering season is often telescoped into a single week and depends on weather conditions.

Pollination biology. This species is facultatively autogamous and often also cleistogamous. The flowers are not fragrant and open only briefly nevertheless putative hybrids with *T. ixioides* and *T. malvina* have been observed, the former hybrid with a few spots on the sepals, the latter with mauve trichomes.

Distinguishing features and notes. The species can be recognised by a combination of features, such as the linear leaf, mid to high leaf fistula, single sterile bract low on scape, dark colour of the plants especially the flower buds, small deep blue flowers with darker linear veins, the narrow post-anther lobe with its bright bands of colour and the tiny irregular notch in its apex and the rather dense white tuft of trichomes. The species was not collected until 2003, but was found to be locally common in years with a wet spring.

Etymology. The epithet *crenulata*, Latin, refers to the crenulate or crinkled surface of the post-anther lobe.

Selected specimens examined at AD

SOUTH AUSTRALIA. **SE:** Black Lagoon, Kangaroo Flat N.F.R., N of Mount Gambier, 12 Nov. 2003, *R.Bates 61627*; Honans N.F.R., S of Glencoe, scattered on firebreaks over peaty sand near lagoons, Nov. 2003, *R.Bates 61637*; Kilsby Lane, off Lake Leake Road, where common on mown road reserve in damp sedge-heath-land, 30 Oct. 2004, *R.Bates 64389*; Below The Bluff, N of Mt Gambier, in peat bog recently burned, 30 Oct. 2004, *R.Bates 64413*; Honans N.F.R., 31 Oct. 2007, *R.Bates 75465*; The Marshes, N of Glencoe, 30 Oct. 2008, *R.Bates 80151* (dupl. MEL).

2. *Thelymitra hygrophila* R.J.Bates, sp. nov.

A Thelymitra holmesii Nicholls habitu caespitoso, floribus plus pedicellis longioribus, lobo post-anthera valde sed non concinne incisurato, lobis lateralibus columnae trichomatibus caespitosis albis (in sicco saepe luteis) differt.

Typus: South Australia, Murray region: Springton Road, just before High Eden turn-off, south side of road, in vernal pool under river red gums, 20 Oct. 2004, *R.Bates 64102*; holo: AD.

Thelymitra sp. Springton Bates, Orchids S. Austral., ver. 1, CD-ROM (2006).

Thelymitra sp. Springton (*R.Bates 63666*) Bates, Orchids S. Austral., ver. 2, CD-ROM (2007).

Thelymitra sp. Springton (*R.Bates 64102*) Bates, Orchids S. Austral., ver. 4, CD-ROM (2009).

Illustration: Bates (2006–2010), as *Thelymitra* sp. Springton, *Thelymitra* sp. Springton (*R.Bates 63666*) and *Thelymitra* sp. Springton (*R.Bates 64102*).

Glabrous, clumping terrestrial orchid to 40 cm tall. Tubers not seen. Leaf linear 10–30 cm long, 2.2–6 mm wide, erect fleshy, canaliculate, ribbed abaxially,

‘v’ shaped in cross section, dark green, sheathing for 2–6 cm above the base, apex acute. Scape 20–40 cm long, 2–4 mm diam., straight, green. Sterile bracts usually 2, linear to linear-lanceolate, 3–6 cm long, green, apex acute. Fertile bracts ovate, acute, 4–10 mm long, 2–5 mm wide, loosely sheathing the pedicels, green, sometimes slightly glaucous. Pedicels 4–5 mm long, slender, within the floral bract. Ovary narrow, cylindrical, 6–12 mm long, 4–6 mm wide. Flowers 1–5: 15–20 mm diam., pale blue to cornflower blue, opening easily on warm humid days, hardly fragrant; buds narrow, slate grey with pale blue margins to sepals. Perianth segments ovate-lanceolate to ovate, 7–11 mm long, 3–8 mm wide, concave, with c. 10 lines; dorsal sepal ovate, subacute; lateral sepals ovate-lanceolate, slightly asymmetric, acute; petals ovate, obtuse to subacute; labellum similar to other petals. Column erect from the end of ovary, 5–7 mm long, 2–3 mm wide, pale blue; post-anther lobe hooding the anther, 3–4 mm long, 2–3 mm wide, rather inflated, slightly tubular, open on the ventral side, strongly curved and flattened dorsally, dark brown to black, the apex thickened and deeply notched, yellow; auxiliary lobes absent; lateral lobes converging, c. 1 mm long, digitiform, porrect at base, curved forwards, each with a dense apical tuft of white trichomes held in front and below the post-anther lobe, the individual trichomes c. 1 mm long, with swollen tips which tend to dry yellowish. Anther inserted about midway along the column, ovoid, 2.5–3 mm long, connective produced into an apical beak to 0.7 mm long; pollinarium c. 1.2 mm long; viscidium circular, c. 0.5 mm long; pollinia friable, mealy, white. Stigma situated at base of column, quadrate, 1.5–2.5 mm long, margins irregular. Capsules elongate-obovoid, 10–15 mm long, 5–7 mm wide suberect, strongly ribbed. **Fig. 1C, 3D–F.**

Distribution and habitat. So far only found in the higher parts of the Mount Lofty Ranges in richer soils of river red gum grassy flats where vernal pools are scattered, either in the smaller pools or around edges of larger ones in rushes and sedges; MU, SL. Probably much more widespread prior to European settlement and likely to have occurred in similar habitat all the way north to the southern Flinders Ranges before the almost total destruction of this habitat through clearing, ploughing or grazing. More recently decreased rainfall means the ponds in which it grows rarely contain water.

Conservation status. Critically **endangered** with future threat through continuing land clearance and drying of its remaining habitat due to climate change (NPWC 2003).

Flowering period. October, usually finished within 3 weeks.

Pollination biology: Neither strongly outcrossing nor autogamous, as not all capsules set seed.

Distinguishing features and notes. Plants without open flowers look like *T. holmesii* because of the slate grey

buds, but the dense clumps of plants, less crowded flowers of a softer blue and the dense white terminal trichomes on the lateral arms of the column serve to set it apart. Unlike *T. holmesii* smaller plants may have a single sterile bract. In many ways the species could be confused with *T. exigua* which is also a clumping species, but has broader leaves, smaller flowers with buds not slate-grey, the trichomes spread along the entire length of the lateral lobes of the column.

The author can remember large populations of this species near Kuitpo in the SL region before the area was planted to pines.

Etymology. From Greek *hygros*, water, and *phelos*, love, indicating that the species is restricted to the vicinity of waterholes.

Specimens examined at AD:

SOUTH AUSTRALIA. **MU:** High Eden Road, reserve in river red gum woodland, 25 Oct. 2005, *R.Bates* 66290. **SL:** Cromer C.P., in ephemeral pond in river red gum flat, 26 Oct. 2005, *R.Bates* 66309; Knott Hill N.F.R., in pond in sedges near red gums, 25 Oct. 2008, *R.Bates* 80099.

3. *Thelymitra latifolia* R.J.Bates, sp. nov.

A Thelymitra peniculata Jeanes *habito robustiore, folio latiore planoque non scapo vaginans, alabatrisc rotundis, floribus pallide malvinis et plus leviter lineolatis, columnae lobo post-anthera non vel vix incisurato et apice crenulato differt.*

Typus: South Australia, Southern Lofty region: Millbrook Reservoir, Pine Peninsula, in regenerating sandy patch, 12 Oct. 2004, *R.Bates* 64051; **holo:** AD; **iso:** MEL.

Thelymitra peniculata Jeanes, Muellieria 19: 50 (2004), partly.

Thelymitra sp. *Latifolia* (*R.Bates* 64108) Bates, Orchids S. Austral., ver. 1, CD-ROM (2006)

Thelymitra sp. *Latifolia* (*R.Bates* 64051) Bates, Orchids S. Austral., ver. 3, CD-ROM (2008).

Thelymitra pauciflora auct. non R.Br.: Weber & Bates in Jessop & Toelken, Fl. S. Austral. 4: 2142 (1986).

Thelymitra peniculata auct. non Jeanes: Jeanes, Muellieria 19: 50 (2004), partly, only as to *R.Bates* 15644 as cited in paper, but including other specimens in AD.

Illustrations: Bates (2008–2010), as *Thelymitra* sp. *Latifolia* (*R.Bates* 64051).

Glabrous terrestrial orchid to 30 cm tall. *Tuber* ovoid 1–2 cm long, 5–10 mm wide. *Leaf* lanceolate, 5–10 cm long, 5–15 mm wide, blade flat, obliquely erect, leathery, dark green with reddish tints mostly at base and on margins, lamina with several longitudinal ridges, not sheathing the scape or sheathing only at extreme base, apex acute. *Scape* 10–30 cm long, 2–4 mm wide, glaucous, green with pink or purplish tints. *Sterile bracts* usually two, linear lanceolate 2–5 cm long, closely sheathing except at the acuminate free apex, green with purplish tints sometimes glaucous. *Fertile bracts* ovate acuminate, 7–15 mm long, 5–8 mm wide somewhat inflated, highly textured, purplish with some pale bloom. *Pedicels* 5–10 mm long, slender. *Ovary* obovoid, 5–8 mm long, 4–5 mm diam., green. *Flowers* 2–8: 14–20



Fig. 2. *T. latifolia*. **A, B** column (front and side view), **C** flower, **D** leaf. * column arms with toothbrush-like tufts of hairs; ** orifice of column.

mm across, pale to mid-blue sometimes mauve or pink, opening briefly and only on warm humid days, mostly in the morning; *buds* rounded, lilac to brown with pale greenish or bluish margins to sepals. *Perianth segments* 6–10 mm long, 4–5 mm wide, concave, shortly apiculate or blunt, with 6–12 longitudinal striations; *dorsal sepal* ovate, sub-acute; *lateral sepals* ovate, often asymmetric, subacute; *petals* obovate, obtuse; *labellum* obovate, obtuse, smaller than other segments. *Column* erect from the end of ovary, 5–6 mm long, 3–4 mm wide, pale pink; *post-anther lobe* hooding the anther, 3–4 mm long, 2–3

mm wide, tubular, curved gradually, yellow and brown or predominantly yellow including the apex, which is not or slightly notched rather than gaping, lightly ribbed longitudinally with somewhat crenulate margins; may appear to gape on pressed material due to squashing; *auxiliary lobes* often present as two short thick spurs on lower apical margins; *lateral lobes* converging 1.2–1.5 mm long, porrect at base, curving gently upwards and forwards with a sub-terminal, elongated, mop-like, untidy tuft of white trichomes, which are held well in front of the post-anther lobe, the individual trichomes 1–1.5 mm long, slender with a thickened apex, often drying a dirty colour. *Anther* inserted above centre of column, ovoid 1.6–1.8 mm long, the connective extended into an apical beak; *pollinarium* 1.5–2 mm long; *viscidium* \pm circular c. 0.5 mm diam.; *pollinia* white, mealy friable rarely seen intact in open flowers. *Stigma* at base of column, ovate-quadrangle, c. 2.2 mm diam., margins irregular. *Capsules* obovoid, 10–11 mm, long 4–8 mm wide, erect and ribbed. **Fig. 1A, 2.**

Distribution and habitat. In South Australia found from the southern Flinders Ranges southward through the Mount Lofty Ranges to the South-east (FR, NL, MU, SL, SE) and probably also in western Victoria. Found in woodlands in various soil types from leached pale sands to yellow gravelly clays and may occur near swamps.

Conservation status. Widespread, locally common and well conserved in conservation parks.

Flowering period. Late September in the north of its range to early November in the south.

Distinguishing features. Easily recognised by the following characters: the broad flat green leaf blade (but not as red as in *T. brevifolia*); the glaucous scape emerging from the leaf base at or near ground-level; the two short sterile bracts and the purplish, minutely tuberculate floral bract, which has a pale bloom; the short lilac buds; rounded flowers in various shades of mauve to blue; the numerous striations on the segments; the post-anther lobe more strongly yellow than most species, which is lightly ribbed apically, apex not markedly inflated, margins crenulate to sub-crenulate. The lateral lobes are directed well in front of the post-anther lobe and the white trichomes form an elongate mop. The flowers are not fragrant.

Etymology. The name *latifolia*, Latin, means flat leaf, as this species has a broad flat leaf on mature flowering plants, although in poor seasons and on smaller plants the leaf may be much reduced in width.

Selected specimens examined at AD

SOUTH AUSTRALIA. **FR:** Alligator Gorge N.P., 27 Sep. 1988, *R. Bates 15644*. **MU:** 'Fernlee Dell', High Eden via Springton, in deep sand under bracken, 17 Oct. 2004, *R. Bates 64045*. **SL:** Boyles Swamp Mylor, 5 Dec. 1980, *R. Bates 879*; Ti Tree Creek Road via Prospect Hill, in pink gum woodland, 8 Nov. 2003, *R. Bates 61781*; Pine Peninsula, Millbrook Reservoir, 3 Nov. 2003, *R. Bates 61475*; Scott Creek C.P., 16 Oct. 2004, *R. Bates*

64009; Scott Creek C.P., Bushrat Ck, 16 Oct. 2004, *R. Bates 64008*; Millbrook Reservoir, Gate 38, open woodland under powerlines, 25 Oct. 2004, *R. Bates 64108*; Lobethal Bushland Reserve, top firebreak, 24 Oct. 2004, *R. Bates 64114*; Mt Bold, Thomas Gully, 2 Nov. 2005, *R. Bates 66408*; SE corner of Mt Bold Reserve, 2 Nov. 2005, *R. Bates 67221*; Peter Ck, Oct. 2007, *R. Bates 75088*; Lenswood Agric. Res. Centre, 20 km E of Adelaide, 15 Oct. 1977, *A.G. Spooner 5407*. **SE:** Pine Hill Soak, on crests of dry sand ridges, 11 Nov. 2003, *R. Bates 61588*; Bangham C.P., sand slopes in stringy bark woodland, Nov. 2003, *R. Bates 61655*; 10 km N of Kalangadoo, 31 Oct. 2004, *R. Bates 64414*; State Forest adjacent to W side of Lower Glenelg River N.P., 24. Oct. 1982, *J.Z. Weber 7831*.

4. *Thelymitra odora* R.J. Bates, sp. nov.

A Thelymitra pauciflora R.Br. *fistula* altiore, una bractea sterili, alabastris atroschistaceis marginibus pallidis, floribus atrocyanellis cum venis fuscioribus et collo nigero, lobo post-anthera laete luteo vel aurantiaco et trichomatibus brevibus densis et floribus fragrantibus differt.

Typus: South Australia, Southern Lofty Region: Lobethal, scrub at the top of ridge, E of bushland reserve, 15 Oct. 2007, *R. Bates 75072*; *holo:* AD, *iso:* MEL.

Thelymitra sp. *Slate Buds* (*R. Bates 64092*), Bates, Orchids S. Austral., ver. 1, CD-ROM (2006).

Thelymitra sp. *Odorata* (*R. Bates 61708*), Bates, Orchids S. Austral., ver. 3, CD-ROM (2008).

Illustrations: Bates (2006–2010), as *Thelymitra* sp. *Slate Buds* (*R. Bates 64092*) and *Thelymitra* sp. *Odorata* (*R. Bates 61708*).

Glabrous terrestrial orchid to 30 cm tall. *Tuber* elongate ovoid to spindle shaped 2–3 cm long, 6–8 mm wide. *Leaf* linear 8–12 cm long, 1.5–2.5 mm wide, erect, canaliculate, not fleshy, slightly ribbed abaxially, dark green with a purplish base, sheathing at the base for 4–8 cm above ground level, apex acute. *Scape* 15–30 cm long, 1–2 mm diam., slender, straight, pale mauve. *Sterile bracts* two, rarely single, linear, 2–5 cm long, sheathing except at the slightly swollen orifice, pink, acute. *Fertile bracts* ovate-acuminate, 5–10 mm long, 2–4 mm wide, sheathing the pedicels, purplish, sub-glaucous, acute. *Pedicels* slender 5–7 mm long. *Ovary* narrow-obovoid, 5–10 mm long, 2–3 mm wide, sub-glaucous. *Flowers* 1–4: 12–14 mm diam., usually deep blue, opening only on warm humid days; *buds* slate coloured, with some powdery bloom, the sepal margins broad, pale grey and blue or white. *Perianth segments* ovate 6–8 mm long, 3–5 mm wide, concave, often shortly apiculate, lines 10–12 moderately distinct; *dorsal sepal* ovate, obtuse to subacute; *lateral sepals* ovate lanceolate, often asymmetric, acute; *petals* ovate, obtuse to apiculate; *labellum* obovate, acute, usually slightly smaller than other segments. *Column* erect from end of ovary, 5–6 mm long, 2–3 mm wide, white or pale blue; *post-anther lobe* hooding the anther, 3–5 mm long, 1–2 mm wide, tubular, dark coloured and ribbed on top, apex yellow or orange, not expanded, shallowly but neatly notched, margins crenulate and slightly incurved; *auxiliary lobes* present as two incurved triangular spurs less than 1



Fig. 3. A–C *T. crenulata*: A, B column (front and side view), C flower. D–F *T. hygrophila*: D, E column (front and side view), F flower. G–H *T. odora*: G column (front and side view), H flower. * column arms with mop-like tufts of hairs.

mm long on the lower apex of the post-anther tube and sometimes touching near the anther apex; *lateral lobes* converging 1.3–1.4 mm long, digitiform, porrect at the glabrous base, curved upwards at right angles, each with a dense mop-like tuft of white trichomes held in front of the post-anther lobe; each trichome 1–1.2 mm long. *Anther* inserted above centre of column ovoid, 1.5–2 mm long, the connective produced into an apical beak 0.2–0.4 mm long; *pollinarium* 1–1.5 mm long; *viscidium* circular c. 0.2 mm diam.; *pollinia* mealy, friable, white. *Stigma* at base of column, quadrate, c. 2.5 long, 2 mm

wide, margins irregular. *Capsules* obovoid, 10–15 mm long, 4–6 mm wide, erect, ribbed. **Fig. 1D, 3G–H.**

Distribution and habitat. So far only known from a small area of the southern Mount Lofty Ranges (Adelaide Hills) from Mount Lofty north to Mount Pleasant and Mt Gawler in pebbly winter seepage areas, particularly on slashed firebreaks where populations of up to a hundred plants may be set up; SL, MU. The species was probably much more widespread before European settlement.

Conservation status. The species is highly localised, never common, with isolated populations in relict damp

woodland sites. A conservation status of **vulnerable** is suggested according to NPWC (2003), indicating the species is vulnerable to extinction. The total population of *T. odora* was estimated at about 2000 plants in 2010.

Flowering period. The flowering season restricted to about two weeks in late October and early November.

Pollination biology. This species is facultatively autogamous and cleistogamous in a cool spring when flowers do not open.

Distinguishing features. A species only readily recognised in early flowering when the slaty grey buds with pale edges are obvious and in contrast to *Thelymitra pauciflora* which flowers earlier in the same area. The unexpanded post-anther lobe with its deep yellow, sometimes orange apex, with its neat 'v' shaped notch also helps to identify the species. This is one of a number of similar species having a powdery white bloom on the floral bract and ovary.

Notes. There may be two subspecies involved, as plants from swampy habitat have larger flowers and a distinct violet fragrance whereas woodland populations have small blooms and a more general floral perfume.

Etymology. From the Latin *odora*, perfumed. This is one of the few species of the *T. pauciflora* complex to have a fragrance.

Selected specimens examined at AD

SOUTH AUSTRALIA. **SL:** Onkaparinga Woollen Mills Reservoir, 16 Nov. 2003, *R.Bates 61708* (site later under water); Lobethal Woodland Reserve, 16 Nov. 2003, *R.Bates 61709*; Warren Reservoir, upper reaches, 16 Nov. 2003, *R.Bates 61711*; Warren Reservoir, near Williamstown 27. Oct. 2003, *R.Bates 61884*; Adelaide Gully Road, Gate 28, top springs in grass and damp woodland, 1 Nov. 2004, *R.Bates 64220*; Lobethal Bushland Reserve, east section, top firebreak, Nov. 2005, *R.Bates 66401*; 2 km N of Lobethal, near hilltop, 10. Nov. 2005, *R.Bates 66614* & *Susan*; Lobethal F.R., north of town on the top firebreak, 30 Oct. 2005, *R.Bates 66966*; Millbrook Scrub, off Adelaide Gully Road, 4 Nov. 2005, *R.Bates 67008*.

5. *Thelymitra orientalis* R.J.Bates, *sp. nov.*

A Thelymitra mucida Fitzg. *plantibus parvulis, floribus paucioribus parvis cum segmentis brevibus obtusis, lobo post-anthera parum argenteo-glaucis, ambobus lobi lateribus perangustibus, trichomatibus erectissimis inter ambos duos insertis adpressisque differt.*

Typus: South Australia, South-east region: The Marshes Forest Reserve, N end of central N-S-track, Nov. 2003, *R.Bates 62078*; *holo:* AD, *iso:* MEL.

Thelymitra sp. '*orientalis*' Bates, *Orchids S. Austral.*, ver. 4, CD-ROM (2009), in text.

Thelymitra mucida subsp. *orientalis* Bates, *Orchids S. Austral.*, ver. 4, CD-ROM (2009), *nom inval.*, in figure caption.

Thelymitra mucida auctt. non Fitzg.: Weber & Bates in Jessop & Toelken, *Fl. S. Austral.* 4: 2141 (1986), partly; Jeanes, *Muelleria* 19: 67 (2004), partly; Bates, *Orchids S. Austral.* ver. 1, CD-ROM (2006).

Illustration: Bates (2009, 2010), as *T. mucida* subsp. *orientalis*.

Glabrous terrestrial orchid to 10 cm tall. *Tuber* ovoid, white, to 1.5 cm long, c. 1 cm diam. *Leaf* filiform, terete to c. 5 cm long, c. 2 mm wide, rigidly erect, green with a red base, obscurely channelled, clasping the base of the scape for 1–2 cm. *Scape* to 10 cm long, c. 1 mm wide, wiry, red tinted, with usually a single flower but occasionally two. *Sterile bracts* 2, lanceolate-ovate, to 10 mm long, strongly clasping the scape, apex obtuse. *Fertile bract* pale purple, ovate, loose, c. 4 mm long, c. 2 mm wide, with minor pale bloom, obtuse to sub-acute. *Pedicel* very slender only 1 mm long; *ovary* dark purple, ovoid, 3–5 mm long, 2–3 mm wide. *Flower* to 10 mm diam., deep blue with magenta tints and 6–8 darker striations; *bud* plump, slate-grey; *perianth segments* shortly ovate, 5–7 mm long, 4–5 mm wide, rounded, apex obtuse or shortly mucronulate; *sepals* cupped, slate grey outside with blue edging, the dorsal sepal hooding the column, *petals* flatter and more rounded, labellum narrower. *Column* very erect, oblong, rich purple, 3–4 mm long, c. 2 mm wide; *post-anther lobe* hooding, 1–2 mm long, c. 1 mm wide, black with very little or no shining silver bloom, apex yellow, divided into two narrow lobes with crenulate, incurved margins; *lateral lobes* c. 2 mm long, c. 1 mm wide, porrect at first then erect, very flat, indigo, the trichomes sparse, slender, 1–2 mm long, yellow with golden apical third, lower trichomes magenta based, the tufts strongly recurved and adpressed inside and outside the two halves of the apical lobe, not exceeding it in height. *Anther* situated behind column centre, ovoid c. 1 mm long, the connective not beaked; *pollinarium* white, to 1 mm long, *viscidium* circular to 0.1 mm diam.; *pollinia* mealy, friable, white. *Stigma* at base of column, quadrate, to 1 mm across, margins smooth. *Capsules* obovoid, 8–10 mm long, 5–6 mm wide, dark green, erect, hardly ribbed. **Fig. 1E, 4A–C.**

Distribution and habitat. Known with certainty only from the western end of Kangaroo Island, the lower South-east of South Australia and (south) western Victoria. *T. orientalis* grows in damp heathy flats and seepage areas in high rainfall districts usually in leached peaty white sands.

Conservation status. Apparently very localised, rare and endangered due to habitat clearance for pine plantations and farms; suggest conservation rating of **endangered**, according to criteria of NPWC (2003).

Flowering period. All collections have been made on hot days in late October or early November.

Pollination biology. The species is facultatively autogamous and may be cleistogamous in cool periods when flowers do not open.

Distinguishing features. Most plants from South Australia and western Victoria previously identified

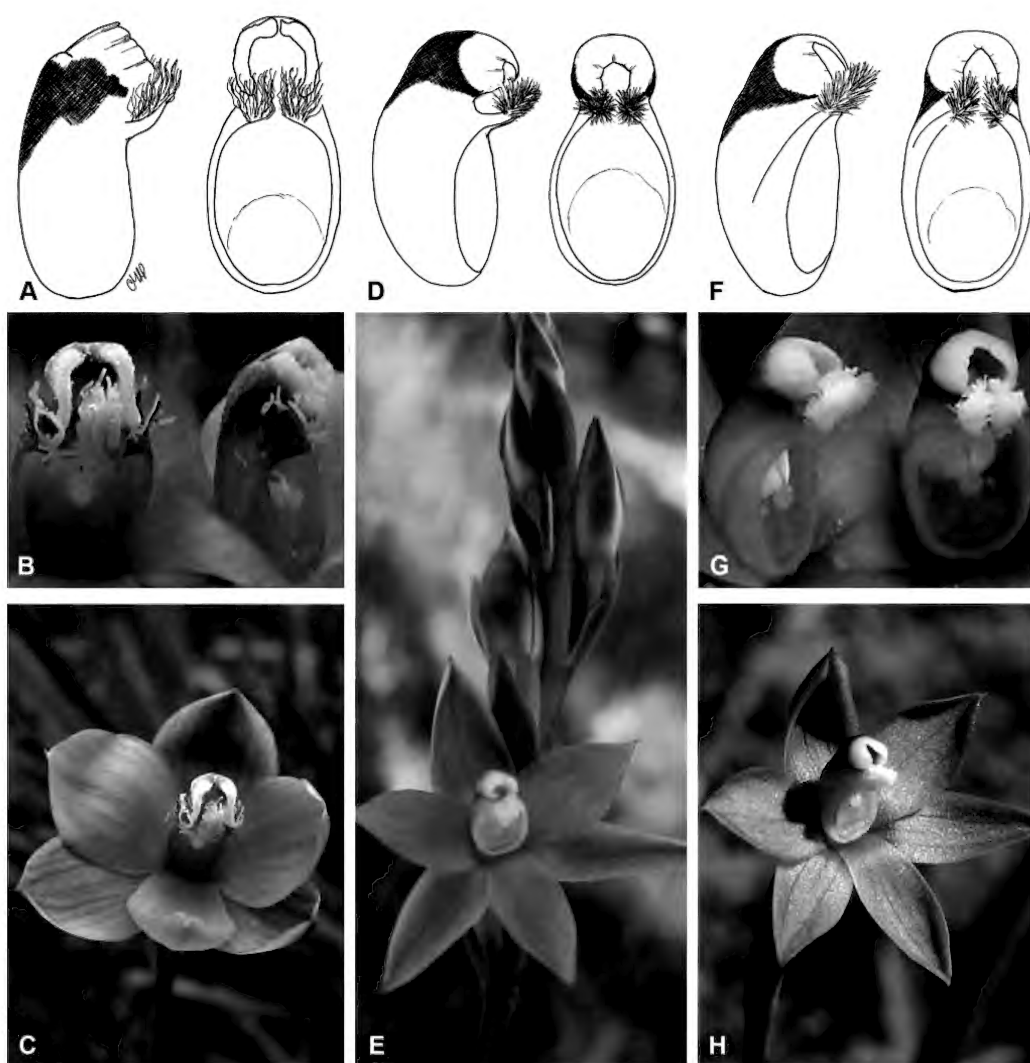


Fig. 4. A–C *T. orientalis*: A, B column (front and side view), C flower. D–E *T. pallidifructus*: D column (front and side view), E flower. F–H *T. rubricaulis*: F, G column (front and side view), H flower.

as *Thelymitra mucida* were placed by Jeanes (2004) in the allied, (recently named) species *Thelymitra inflata* Jeanes and *T. lucida* Jeanes. These species both differ from *T. mucida* in being quite robust, with larger, deeper blue flowers, more inflated post-anther lobe and different trichome arrangement. Some collections have since been re-determined as *T. merraniae*. Only a few South Australian and Western Victorian collections were left under *T. mucida* which is quite a common species in South-western Australia.

The remaining South Australian and western Victorian specimens are far smaller than Western

Australian plants, most are single flowered with a short filiform leaf, most have little or no bloom on the column and the trichomes are strongly adpressed to and between the two halves of the post-anther lobe. On the suggestion of Jeanes (pers. comm., 2006) these have been treated here as a separate species, *T. orientalis*, rather than a subspecies of *T. mucida*.

Note. It is yet to be ascertained whether *T. mucida* sensu stricto occurs in the eastern States. Although I have seen some images of flowers from South Australia that would appear to be of this taxon I have seen no good specimens.

It is likely that there are other taxa involved in the *Thelymitra mucida* complex since there is considerable variation in size and morphology of flowers.

Etymology. The name *orientalis*, Latin, of the East, has been chosen to show that this is an eastern Australian species similar to the Western Australian species *T. mucida*.

Specimens examined at AD

SOUTH AUSTRALIA. **KI:** Opposite Mt Taylor C.P., S coast of Kangaroo Island, in peat bog, 23 Oct. 2008, *R.Bates 80092*. **SE:** The Marshes N.F.R., centre track, Nov. 2005, *R.Bates 63452*.

VICTORIA. **SW:** Syphon Road swamp, Grampians, 12 Nov. 1985, *R.Bates 6520*.

6. *Thelymitra pallidifructus* R.J.Bates, sp. nov.

A Thelymitra pauciflora R.Br. *una bractea sterili, floribus alabastrisque lilacinis, ovario pallidissime flavivirente (in sicco saepe pallide), lobi post-antherae apice anguste crenulato, trichomatibus minus confertis, florenti postea, et crescendo plerumque in turbario differt.*

Typus: South Australia, South East region: Whennan Native Forest Reserve, Mt Burr, Top track in sandy scrublands, 30 Oct. 2004, *R.Bates 64170*; holo: AD; iso: MEL.

Thelymitra pauciflora R.Br., Prodr. 314 (1810), partly.

Thelymitra sp. *Pale capsules* (*R.Bates 64170*) Bates, Orchids S. Austral., ver. 2, CD-ROM (2007).

Illustration: Bates (2008), as *Thelymitra* sp. *Pale capsules* (*R.Bates 64170*).

Glabrous terrestrial orchid to 30 cm tall. *Tubers* ovoid, 10–20 mm long, 5–8 mm wide; *Leaf* shortly linear 10–15 cm long, 1–2 mm wide, obliquely erect, fleshy, canaliculate at first, lamina becoming flat distally on larger specimens, ribbed abaxially, green with a red tinted base, sheathing the scape for 3–5 cm, fistula narrow, apex gradually acuminate. *Scape* 15–30 cm long, 1–2 mm diam., slender, usually slightly flexuose, green or pinkish. *Sterile bract* single, linear lanceolate, 2–3 cm long, pale pink or green, closely sheathing, apex acute. *Fertile bracts* short, ovate to quadrate, 8–10 mm long, 4–6 mm wide, pinkish, glaucous. *Pedicels* 1–3 mm long, grading into the ovary. *Ovary* narrow-obovoid, 5–10 mm long, 3–5 mm wide, a pale yellow-green on live material, remaining pale when dried fresh. *Flowers* 2–10: 10–15 mm across, usually lilac but sometimes pale blue, opening only on warm humid days and then only briefly; *buds* slender, lilac and green with pale lilac sepal edges. *Perianth* segments 6–10 mm long, 3–6 mm wide, concave, not apiculate; *dorsal sepal* ovate, obtuse to sub-acute, with c. 5 indistinct lines, often hooding the column; *lateral sepals* ovate-lanceolate, with indistinct lines, obtuse to sub-acute; *petals* somewhat broader, ovate, obtuse or sub-acute; *labellum* smaller, ovate-oblong, apex obtuse. *Column* erect from the end of the ovary, 4–5 mm long, 2–3 mm wide, quadrate, white or palest lilac; *post-anther lobe* hooding the anther, c. 2 mm long, tubular, curved forward, pale yellow with

a brown to purple brown collar at the base but, apex hardly to irregularly notched, not thickened, lobes not inflated, margins sub-crenulate to dentate, *auxiliary lobes* indistinct; *lateral lobes* converging, 0.8–11 mm long, digitiform, curved sharply upwards near the base, each with an untidy mop-like arrangement of white trichomes, individual trichomes to 1 mm long, held in front of the post-anther lobes not embracing them. *Anther* inserted midway along the column, ovoid, 2–2.5 mm long, connective produced into an apical beak 0.5 mm long; *pollinarium* 1.3–1.5 mm long; *viscidium* more or less circular c. 0.1 mm across; *pollinia* friable, mealy white. *Stigma* situated at base of column, concave, quadrate, c. 1.7 mm wide., margins smooth. *Capsules* narrowly obovoid, 10–15 mm long, 5–7 mm wide, ribbed, pale greenish-yellow until dried. **Fig. 1F, 4D–E.**

Distribution and habitat. Widespread and locally common from the southern Mount Lofty Ranges, western Kangaroo Island and the lower South-east, mostly in damp or swampy heathland often in sandy soils, often in slashed fire breaks and lightly grazed areas usually with other *Thelymitra* spp. (MU, SL, KI, SE).

Conservation status. Widespread, common and well conserved in conservation parks.

Flowering period. Late October to mid November, the flowering season very short as in other self-pollinated, later flowered sun-orchids.

Pollination biology. The short lived flowers are mostly inbreeding, autogamous even cleistogamous, but hybrids are recorded with more outcrossing species such as *T. ixioides* and *T. nuda*.

Distinguishing features and notes. *Thelymitra pallidifructus* is most easily recognised by the combination of high leaf fistula, short stature, single sterile bract, pale yellow-green ovaries and fresh capsules, lilac buds and flowers, and crenulate post-anther lobe apex. Like many members of the sub-complex the species sets up large colonies in suitable disturbed habitat such as slashed fire breaks cut through damp heath. Long thought to be distinct, but only recently have detailed studies showed it to be constant and habitat specific.

Etymology. From the Latin *pallens*, pale, and *fructus*, a fruit, in reference to the pale ovary and developing capsule. The epithet is treated as a noun in apposition.

Selected specimens examined at AD

SOUTH AUSTRALIA. **MU:** Kaiser Stuhl N.F.R. in boggy woodland, late Oct. 2005, *R.Bates 67395*. **SL:** Mylor town common, Nov. 2004, *R.Bates 64439*; Mt Bold Reserve on firebreaks in slashed heath, 5 Nov. 2005, *R.Bates 67086*; Mt Compass, 30 Oct. 1921, *J.B.Cleland 248*. **KI:** Intersection of Playford Hwy and Cassini Rd, 26 Oct. 1990, *B.M.Overton 1409*; 5.5 km SE of Cape Forbin, 24 Oct. 1990, *A.C.Robinson npki-79*; Willson River, 5 Oct. 1913, *R.S.Rogers 5059*; De Mole River in swampy places, Oct. 1909, Mr Smith the lighthouse keeper, sub *R.S.Rogers 5068*. **SE:** Old Comaun Road, 5.5 km N of Coonawarra junction, Nov. 2003, *R.Bates*

61542; Kangaroo Flat N.F.R., 11 Nov. 2003, *R.Bates* 61639 (dupl. MEL); Nangwarry, 29 Oct. 2004, *R.Bates* 62480; Lake Leake Road, in mown sand-heath, 30 Oct. 2004, *R.Bates* 64417; Tantanoola Forest, Nov 2003, *R.Bates* s.n.; Mt Burr F.R., 11 Nov. 1959, *P.G.Wilson* 1105.

7. *Thelymitra rubricaulis* R.J.Bates, *sp. nov.*

A Thelymitra pauciflora R.Br. *scapo bracteaeque maronino ad purpureo, folio saepe colorato simili, una bractea parva sterili, scapo bracteaeque valde pallida glaucidine, floribus multiplicibus cum apice minuto lobi post-antherae et anguste 'v'-formi incisurato, et crescenti in turbario differt.*

Typus: South Australia, South-East region: Whennan Scrub Forest Reserve, near Mt Burr, on Track WH1, slashed peat bog on edge of sandy track, 29 Oct. 2004, *R.Bates* 64155; holo: AD.

Thelymitra sp. *Rubricaulis* (*R.Bates* 64273) Bates, Orchids S. Austral., ver. 1, CD-ROM (2006).

Illustration: Bates (2006–2010) as *Thelymitra* sp. *Rubricaulis* (*R.Bates* 64273).

Glabrous terrestrial orchid to 35 cm tall. *Tubers* narrowly ovoid, 1–2 cm long, 4–8 mm wide. *Leaf* linear, blade short, 8–15 cm long, 2–3 (–5) mm wide, canaliculate to flat, erect, dark green to maroon with red to purplish, tubular base sheathing the scape for 4–10 cm, apex shortly acute. *Scape* 15–35 cm long, 1–2 cm wide, slender, straight, bright red to purple, usually with a pale bloom which is easily rubbed off. *Sterile bract* single, linear-lanceolate, 2–4 cm long, mostly sheathing, deep maroon with pale bloom, apex short and acute. *Fertile bracts* small, ovate-acute, 4–10 mm long, 2–3 mm wide, sheathing only the base of the pedicel, maroon with pale powdery bloom. *Pedicels* 4–15 mm long, slender, purplish. *Ovary* narrow-ovoid, 7–15 mm long, 2–4 mm wide, deep pink to maroon, often with pale bloom at the base and extending onto the pedicel. *Flowers* 1–8: 9–12 mm across, deep blue to mauve, opening only on warm humid days and then only briefly; *buds* narrow, maroon with pale sepal edges, some indistinct bloom. *Perianth segments* 6–8 mm long, 2–3 mm wide, concave, not apiculate with 6–8 darker parallel lines; *dorsal sepal* ovate, obtuse to subacute; *lateral sepals* lanceolate, symmetrical, acute; *petals* ovate to obovate, obtuse to sub-acute; *labellum* obovate, obtuse slightly smaller than sepals. *Column* erect from end of ovary, 4–5 mm long, 2–3 mm wide, purplish; *post-anther lobe* hooding the anther, 2–3 mm long, 1.5–2 mm wide, tubular, compressed dorsally, curving past the middle, hardly compressed, almost black at the base, apex deep yellow, neatly notched, the lobes not inflated, margins smooth, not thickened or crenulate, flowers soon collapsing when pollinated; *auxiliary lobes* absent; *lateral lobes* more or less parallel, c. 1.2 mm long, porrect at the glabrous base, obliquely erect, each with an elongated tuft of dense, white, tidy trichomes embracing the post-anther lobe, individual trichomes c. 1 mm long, not swollen at tip. *Anther* inserted about the centre of the column, ovoid, 2 mm long, the connective produced into a short beak; *viscidium* more or less

circular, c. 0.5 mm wide; *pollinia* friable, mealy, white. *Stigma* at base of column, ovate-quadrate, 1.5–2.5 mm long, c. 2 mm wide., margins irregular. *Capsules* elongate-ovoid, 10–20 mm long, 4–8 mm wide, dark coloured, erect, ribbed. **Fig. 1G, 3F–H.**

Distribution and habitat. Restricted in South Australia to the lower South-East in an area from Penola to Mount Burr to Glencoe to Nangwarry. Found only on slashed firebreaks and track-sides in peaty sand usually adjacent bogs and seepage slopes in heath and low woodland with bracken often dominant (SE). Probably also in similar habitat in south-western Victoria and may once have occurred in peat bogs of the SL and KI regions.

Conservation status. Localised and rare but does occur in colonies of up to fifty plants; suggested rating of **vulnerable** according to the criteria of NPWC (2003), as both, the predicted drying of the climate and some present management plans make the species vulnerable to extinction.

Flowering. Taking into account the swampy, cold habitat, the species flowers remarkably early, usually finishing flowering before the end of October.

Distinguishing features and notes. Easily distinguished from the rest of the complex by the bright pink to purple-maroon colour of the stems, the narrow leaf with high fistula, the slender yet remarkably rigid inflorescence with its single sterile bract, the pale bloom on any part of the plant, the long capsules, the deep blue flowers, small column and small neatly incised notch in the post-anther lobe. It is surprising that the species was not collected in South Australia until 2004 given the vivid colouring of plants. However the early flowering (for the habitat) and rarely opening blooms would prevent most collectors from gathering material. The author has not yet seen plants in full bloom, but the flowers do not appear to produce any fragrance. Hybrids are not known.

Etymology. From Latin *ruber*, red, and *caulis*, a stem, reflecting the deeply coloured inflorescence. The epithet is treated as a noun in apposition.

Specimens examined at AD

SOUTH AUSTRALIA. **SE:** 3.6 km N of The Marshes (N.F.R.), 11 Oct. 2003, *R.Bates* 61608; Whennans F.R. on top track, mown edges, 29 Oct. 2004, *R.Bates* 64176; Adjacent Whennan S.F., 30 Oct., s.anno, *R.Bates* 64273; Mt MacIntyre N.F.R., 30 Oct. 2004, *R.Bates* 64419; Lake Leake Road north of Glencoe, Oct. 2004, *R.Bates* 64461; Nangwarry Forest (all in seed), Oct. 2005, *R.Bates* 66301; The Marshes (E), 30 Oct. 2008, *R.Bates* 80154 (dupl. MEL).

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¹ EDITORIAL NOTE: The publication history of the *Orchids of South Australia* CD-ROM is complex, as the dates when the chapters were up-dated are not known. For simplicity, a new version is listed here for each year. The CD-ROM was at times available from NOSSA and also from the author. Chapters were also available at the Society's web-site in the past. Copies are lodged with the State Herbarium of South Australia, Adelaide.

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Genetics of white-flowered cultivars derived from *Watsonia borbonica* (Iridaceae)

D.A. Cooke

58 Gardiner Avenue, Warradale, South Australia 5046

Email: david.cooke@sa.gov.au

Abstract

Breeding experiments suggest that the occurrence of white (acyanic) flowers in several cultivars derived from *Watsonia borbonica* (Pourr.) Goldblatt is determined by a single recessive allele. Many *Watsonia* cultivars have been characterised simply as ‘white-flowered’; but descriptions based on several characters are necessary if cultivars with unique genotypes are to be differentiated without ambiguity.

Keywords: *Watsonia*, Iridaceae, cultivated plants

Introduction

The chemical pathways by which flavonoids, including the red to blue coloured anthocyanins, are synthesised in plants have been thoroughly documented (Winkel-Shirley 2001). As these pathways are similar throughout the angiosperms, mutations with analogous effects on flower colour may be found in various genera. Species that normally produce anthocyanin-pigmented flowers will produce white or cream flowers when a mutation blocks any one of several steps in anthocyanin synthesis (Harrison & Stickland 1974; Mato et al. 2000). The superficially similar white flowers of various cultivars bred from the same species may therefore result from independent mutations at different loci. For example, Onozaki et al. (1999) were able to classify various cultivars of *Dianthus caryophyllus* bearing pure white or ivory-white flowers into three groups according to the stage at which anthocyanin synthesis is blocked by the absence of a necessary enzyme. A block may occur at the formation of chalcones by the enzyme chalcone synthase. Another, and later, stage that may be blocked is the conversion of flavanones to dihydroflavonols by flavanone 3-hydroxylase; in the absence of this enzyme, flavanones accumulate and are then converted to flavones by an alternative pathway involving flavanone isomerase (Onozaki et al., 1999). Although almost colourless, these flavones can be detected by the bright yellow colour produced when the flower is exposed to ammonia gas (Buxton 1932). This colour rapidly fades when the ammonia is removed, being due to a reversible auxochromic reaction (Tilley 2000).

The term albino has sometimes been applied to white-flowered mutants within species that typically bear conspicuously pigmented flowers. However, albinism in plants may also mean the absence of all pigments including chlorophyll. To avoid ambiguity here, I have followed current practice in using the term acyanic, i.e. lacking anthocyanins.

Plants with anthocyanin-pigmented flowers normally produce at least traces of red-purple pigmentation in the leaves and stems, particularly under conditions of stress. However, acyanic variants typically have pure green leaves and stems as these also lack anthocyanins. Armitage (1945) listed 100 species from the flora of Britain that demonstrate this colour polymorphism in both flowers and vegetative organs.

Perianth colour in *Watsonia* species typically ranges from pale pink or mauve-pink to intense red, purple or orange, due to the presence of various concentrations of anthocyanin pigments. The cultivars bred from these species show a somewhat wider range, from pastel pinks to mauve, purple, maroon, salmon, vermilion or combinations of these colours. The only anthocyanins so far characterised from *Watsonia* species are the orange to red pelargonidin derivatives (Harborne 1963). But the colours of mauve and purple must be due to another anthocyanin. This may be delphinidin, as its colourless precursor protodelphinidin and the corresponding flavonol myricetin have been isolated from leaves of the mauve-pink flowered *W. borbonica* (Williams et al. 1986). The range of flower colours in the genus implies that anthocyanin synthesis is influenced by several loci. However, a mutation that blocks all anthocyanin production is necessarily epistatic to all of these loci, resulting in unpigmented white flowers.

The **acyanic syndrome** in *Watsonia* is here defined as: Leaf bases and margins green; inflorescence axis green; floral bracts green-herbaceous to brown-scarious; perianth pure white or with a faint fugitive pink tinge; anthers cream.

In comparison, the **cyanic wild-type** has: Leaf bases green or suffused with red; leaf margins green to red-brown; inflorescence axis green to deep red or purple; floral bracts green-herbaceous to red, purple or scarious; perianth coloured pink, red, orange or purple; anthers purple.

The degree of anthocyanin pigmentation in the foliage and inflorescence axis of cyanic *Watsonia* varies widely with genotype and environment, being strongest in plants grown in full sun. The purple anthers are a more uniform character, with pollen grains and the anther wall darkly pigmented even in plants grown in the shade or with pale pink perianths. Anthers of acyanic *Watsonia* are cream in appearance due to the pale yellow pollen enclosed in a colourless anther wall.

This study aims to investigate the genetic basis of the acyanic syndrome in *Watsonia* and to resolve whether this basis is the same in the various acyanic accessions available for study.

Materials and methods

The following clonal accessions were used in experimental crosses and/or tests for flavones:

- *Watsonia aletroides* (Burm.f.) Ker Gawl. Perianth red; anthers purple; from a suburban Adelaide garden, and within the circumscription of this species by Goldblatt (1989).
- *Watsonia hysteronantha* Mathews & L.Bolus Perianth vermilion-red; anthers purple; grown from wild-collected seed imported from South Africa, and within the circumscription of this species by Goldblatt (1989).
- *Watsonia meriana* (L.) Mill. var. *meriana*. Perianth vermilion-red; anthers purple; within the circumscription of this species by Goldblatt (1989). Collected from a naturalised population at Hahndorf (Cooke 1998a).
- *Watsonia borbonica* (Pourr.) Goldblatt 'Arderne's White'. Perianth white; perianth lobes 30–37 mm long; style exceeding anthers; anthers cream. (Fig. 1) From a suburban Adelaide garden, and closely matching the illustration of this cultivar in Goldblatt (1989), notably in the almost equilateral orientation of the stamens and the obovoid, very obtuse capsule. Also matched to a photograph of the isoelectotype of *W. ardernei* Mathews & L.Bolus.
- *Watsonia* 'Lilac Towers'. Perianth deep pink; anthers purple; a cultivar derived from *W. borbonica* and probably also *W. meriana* (Cooke 2005).
- *Watsonia* 'Jessie'. Perianth flesh-pink; anthers purple; a cultivar derived from *W. borbonica* and *W. meriana* (Cooke 1998b).
- *Watsonia* 'Leng'. Perianth mauve-pink; anthers purple; a cultivar derived mainly from *W. borbonica* (Cooke 1998b).
- *Watsonia* 'Ivory Towers'. Perianth white, showing a fugitive pink tinge when opening at low temperatures; perianth lobes 32–40 mm long; style exceeding anthers; anthers cream. A commercially available cultivar (Tesselaar 2000) with a similar morphology to *W. borbonica*.
- *Watsonia* Accession 5. Perianth white; style equal to anthers; anthers cream; differing morphologically from 'Arderne's White' most visibly in the shorter, broader and slightly gibbous perianth tube and the more densely



Fig. 1. *Watsonia borbonica* 'Arderne's White', from material used in this study.

branched inflorescence; from a suburban Adelaide garden.

- *Watsonia* Accession 17. Perianth white, showing a pink tinge when opening at low temperatures; style shorter than anthers; anthers cream. Collected from a roadside at Longwood, South Australia, resembling descriptions of Cronin's 'Ballarat' cited by Cooke (1998b) and with a similar morphology to *W. borbonica*.
- *Watsonia* Accession 36. Perianth pink; anthers purple; from a suburban Adelaide garden resembling descriptions of Cronin's 'Australia' cited by Cooke (1998b) and with a similar morphology to *W. borbonica*.
- *Watsonia* Accession 89. Perianth sometimes pink-tinged in bud but opening pure white; perianth lobes 36–42 mm long; style subequal to anthers; anthers cream. Cronin material (Cooke 1998b), with a similar morphology to *W. borbonica* from a former nursery at Chudleigh Park Gardens, Victoria.
- *Watsonia* Accession 91. Perianth white; perianth lobes 36–45 mm long; style exceeding anthers; anthers cream. Cronin material from Chudleigh Park Gardens, and resembling descriptions of Cronin's 'Hobart' cited by Cooke (1998b), with a similar morphology to *W. borbonica*.

1. Experimental crosses

Flowers of all the above are protandrous, usually remaining open for 4–5 days: the anthers dehisce on day 1, a few hours after anthesis, and the stigmas become receptive on day 3. Flowers to be used as ovule parents were emasculated just before anthesis and the style enclosed in a 3 cm length of plastic drinking straw. Pollen was transferred from newly dehiscent anthers of the pollen parent using a toothpick on days 2 and 3.

Seed was sown in the autumn after its production, in trays of Nu-Erth™ potting mix (pH approximately 6) with added Nitrophoska™ fertilizer and potassium sulphate. Plants were grown to flowering size outdoors in 300 mm pots of the same mixture; they began to flower in either the second or third spring after germination.

2. Test for flavone accumulation

Freshly picked flowers of each acyanic *Watsonia* accession and 7 white or cream flowered control species were suspended in a enclosed 500 ml jars over 10 ml of 50 g/L ammonia solution. Flowers were scored for any colour change after 20 minutes, as irreversible blackening and necrosis occurs if exposure to ammonia continues beyond this time. A flower was also removed from the ammonia gas after 20 minutes and allowed to stand in air for 90 minutes.

Results

1. Experimental crosses

Table 1 lists the crosses made between *Watsonia* accessions. The F₁ generations were scored for acyanic or cyanic pigmentation.

It was also observed that all F₁ progeny of *W. borbonica* 'Arderne's White' × *W. meriana* had a mauve-pink (RHS 66C) perianth colour similar to wild-type *W. borbonica* rather than the vermilion red of the pollen parent.

F₂ generations were then bred from some of the individual progeny from crosses 1, 2 and 3 above. The results are summarised in Table 3.

2. Test for flavone accumulation

Results for 15 acyanic *Watsonia* and 6 white or cream flowered species from other genera are listed in Table 3.

In contrast to the bright yellow reaction in most of the control species, each of the acyanic *Watsonia* flowers tested showed only localised areas of faint grey-yellow at 20 minutes exposure before blackening completely within two hours. It is concluded that significant levels of flavone accumulation do not occur in these flowers.

Discussion

From Table 1, it will be seen that:

- F₁ crosses with a cyanic wild-type species as one parent produced only cyanic progeny (crosses 1 to 5).
- An F₁ cross between one cyanic cultivated form and an acyanic produced almost equal numbers of cyanic and acyanic (cross 6).
- F₁ crosses between two acyanic plants produced only acyanic progeny (crosses 7 and 8).
- F₁ crosses among three cyanic named cultivars produced a minority of acyanic progeny (crosses 9 and 10).

The ratios of cyanic: acyanic observed in the F₁ generations are consistent with the hypothesis that acyanic flowers are determined by a single locus with alleles here symbolised as *a* (acyanic, recessive) and *A* (cyanic, dominant). Genotypes inferred from this hypothesis for the accessions used are shown in Table 2. It is deduced that the related species (*W. aletroides*, *W. hysternantha* and *W. meriana*) are most probably homozygous for the dominant cyanic *A* allele; the acyanic plants (*W. borbonica* 'Arderne's White', accession 5, accession 17, accession 91) are most probably homozygous for the recessive *a*; and the four cultivars with cyanic pigmentation (*W. 'Jessie'*, *W. 'Leng'*, *W. 'Lilac Towers'*, accession 36) would be heterozygous. It was not possible to test this hypothesis in the most direct way by self-pollinating the putative heterozygotes due to the high degree of self-incompatibility in *Watsonia*. Instead, the F₂ generation of three crosses using *W. 'Lilac Towers'* was used as a test: the reappearance of a minority of acyanic plants in some of the F₂ derived from each of the F₁ crosses 1–3 (Table 3) supports the hypothesis. Fortuitously, the outcome of F₁ crosses of *W. 'Jessie'* with *W. 'Leng'* or *W. 'Lilac Towers'* approached the ratio of 3:1 expected in crosses between parents heterozygous for a single locus. However, in view of the small numbers of plants grown

Table 1. F₁ crosses between cyanic (coloured) and acyanic (white-flowered) *Watsonia* accessions.

Cross no.	Ovule parent	Pollen parent	Numbers of progeny	
			Cyanic	Acyanic
1	<i>W. 'Lilac Towers'</i> (cyanic)	<i>W. aletroides</i> (cyanic)	12	0
2	<i>W. 'Lilac Towers'</i> (cyanic)	<i>W. hysternantha</i> (cyanic)	28	0
3	<i>W. 'Lilac Towers'</i> (cyanic)	<i>W. meriana</i> (cyanic)	23	0
4	<i>W. borbonica</i> 'Arderne's White' (acyanic)	<i>W. meriana</i> (cyanic)	4	0
5	accession 91 (acyanic)	<i>W. hysternantha</i> (cyanic)	8	0
6	accession 36 (cyanic)	<i>W. borbonica</i> 'Arderne's White' (acyanic)	7	8
7	accession 5 (acyanic)	<i>W. borbonica</i> 'Arderne's White' (acyanic)	0	15
8	accession 17 (acyanic)	<i>W. borbonica</i> 'Arderne's White' (acyanic)	0	18
9	<i>W. 'Jessie'</i> (cyanic)	<i>W. 'Lilac Towers'</i> (cyanic)	6	2
10	<i>W. 'Leng'</i> (cyanic)	<i>W. 'Jessie'</i> (cyanic)	7	2

Table 2. Genotypes of *Watsonia* accessions, dominant **A** (coloured) and recessive **a** (acyanic) inferred from Tab. 1.

<i>Watsonia aletroides</i>	AA
<i>W. hysteraantha</i>	AA
<i>W. meriana</i>	AA
<i>W. borbonica</i> 'Arderne's White'	aa
Accession 5	aa
Accession 17	aa
Accession 91	aa
<i>Watsonia</i> 'Jessie'	Aa
<i>Watsonia</i> 'Leng'	Aa
<i>Watsonia</i> 'Lilac Towers'	Aa
Accession 36	Aa

to flowering size, a statistical analysis was not justified and the results are presented here as qualitative pedigree data.

When opening in cool overcast weather, flowers of some of the acyanics (for example, accession 17) develop a pink tinge that can be accentuated by keeping buds close to anthesis in a refrigerator at 4° C for 24 hours. The possibility that these acyanics are due to a complementary mutation at a separate locus is eliminated by the results of cross 7, which produced only acyanic progeny (Table 1). If two loci had been involved, only cyanic progeny would have been expected from this cross. On the other hand, the possibility that more than one mutation with the same effect has occurred independently at the same locus cannot be ruled out. The *A* locus in *Watsonia* presents a parallel to the *C* locus described by Brieger & Mangelsdorf (1926) in *Nicotiana sanderae*, where homozygous recessives are also acyanic and produce white flowers that may become pink tinged at low temperatures.

None of the acyanic *Watsonia* accessions examined accumulated visible amounts of either the bright yellow chalcones or the paler yellow flavonols. Nor did any of them show the clear, bright yellow reaction with ammonia diagnostic of flavone accumulation (Table 4). It is therefore concluded that their acyanic state is not due to the absence or down-regulation of flavanone 3-hydroxylase, but that flavonoid synthesis is blocked at some earlier stage of the biosynthetic pathway. This conclusion is consistent with the inference that the acyanic state in all these plants is determined by a mutation at the same locus. It is further hypothesised that this mutation may act by down-regulating or inhibiting the production of chalcone synthase, consequently preventing the formation of anthocyanins or other coloured flavonoids.

Many *Watsonia* cultivars have been characterised in horticultural literature and catalogues simply as 'white-flowered'. However, a named cultivar of an ornamental perennial is normally a vegetatively propagated clone (or genet) with fixed horticultural properties due to the identical genotype of all ramets bearing that name. If ambiguity is to be avoided, the names of such cultivars must be supported by a description based on several

Table 3. F2 crosses between progeny of *Watsonia* 'Lilac Towers'; parents are identified by the cross numbers 1–3 from Tab. 1, with letters distinguishing individual plants selected from each of these F1 crosses.

Ovule parent	Pollen parent	Numbers of progeny	
		Cyanic	Acyanic
1g	1b	5	2
2b	2g	4	0
2g	2h	6	2
2h	2i	7	3
2i	2j	8	0
3c	3b	13	3
3i	3f	19	0

characters, and ideally by a type specimen and molecular data as well. Ornamental cultivars are selected for flower colour and form, as well as for vegetative growth traits that make them 'gardenable', i.e. convenient for use in gardens. Other characters that are not directly selected may be useful indicators to distinguish similar cultivars. In *Watsonia* hybrids, such characters include the relative length of the style, shape of floral bracts, orientation of stamens and shape of the seed capsule.

Cultonomy

Watsonia borbonica (Pourr.) Goldblatt 'Arderne's White' B.Mathew

Kew Mag. 11: 39 (1994) ut *Watsonia borbonica* (Pourr.) Goldblatt subsp. *ardernei* (Sander) Goldblatt 'Arderne's White'.

Watsonia ardernei Sander, Sander's New Plants for 1897 18–20 & fig. (1897). — *Watsonia borbonica* subsp. *ardernei* (Sander) Goldblatt, Ann. Kirstenbosch Bot. Gard. 19: 35 (1989), pro parte. — **Lectotype:** Illustration in Sander's New Plants for 1897, fide Goldblatt, Ann. Missouri Bot. Gard. 74: 572 (1987).

Watsonia ardernei Mathews & L.Bolus, Ann. Bolus Herb. 4: 25–26 (1925), nom. illeg. non Sander (1897). — **Lectotype:** South Africa, Cape, Romans River Farm, Tulbagh Distr. (cult. Kirstenbosch), *Tredgold s.n.* (BOL 17839), n.v., fide Goldblatt, Ann. Missouri Bot. Gard. 74: 572 (1987). **Isotype:** PRE 89215-0 ex BOL 17839, n.v., photo seen.

Watsonia pyramidata 'Ardernei' Marais, Kew Bull. 34: 172 (1980).

Watsonia alba Arderne, Garden (London, 1871–1927) 63: 229 (1893). — **Lectotype:** Illustration in Garden (London 1871–1927), fide Goldblatt, Ann. Kirstenbosch Bot. Gard. 19: 35 (1989).

Watsonia iridifolia Ker Gawl. var. *obrienii* N.E.Br. Gard. Chron. ser. 3, 6: 350 (1889), as '*obrienii*' — **Lectotype:** "from the garden of J. O'Brien, Sept 3 1889" (K 320450), fide Goldblatt, Ann. Kirstenbosch Bot. Gard. 19: 35 (1989), n.v., photo seen. **Isotype:** K 320451, n.v., photo seen.

Watsonia obrienii Tubergen, Gard. Chron. ser. 3, 16: 701 (1894), nom. nud.

Illustration. L.Bolus, Fl. Pl. South Africa 19: t. 750 (1939), as *W. ardernei* Mathews & L.Bolus; Goldblatt, Ann. Kirstenbosch Bot. Gard. 19: t. 3., as *W. borbonica* subsp. *ardernei* (Sander) Goldblatt.

Typification. The lectotype illustration of *W. ardernei* Sander is a monochrome photolithograph of a gouache painting showing little detail as it was produced for a retail catalogue. The subject is compressed, with the scapes shortened so the inflorescences arise near ground level. The illustration confirms that the plant is a *Watsonia* with the facies of *W. borbonica*, broad ensiform leaves and white flowers with relatively long perianth tubes, but there is no scale and such details as stamen arrangement are not indicated. This illustration was designated as the lectotype by Goldblatt (1987) and later reconfirmed (Goldblatt, 1989). The lectotype illustration of *W. alba* Arderne is a steel engraving showing flowers resembling those of 'Arderne's White' in closeup, but with no detail of stamens or style. The lectotypes of *W. iridifolia* Ker Gawl. var. *obrienii* N.E.Br. and *W. ardernei* Mathews & L.Bolus agree in all essentials, consistent with statements that they are from the same vegetatively propagated stock.

Nomenclatural history

The origin and synonymy of the original acyanic mutant of *Watsonia borbonica* has been covered by Goldblatt (1989) and Mathew (1994). A single acyanic plant of this species was collected from a pink-flowered population at Romans River farm, Cape Province by H.M. Arderne who grew it on his property 'The Hill' at Claremont, Capetown. Around 1888, James O'Brien of Harrow introduced the clone to England and propagated it as *W. iridifolia* var. *obrienii* (Brown 1889).

It was exhibited at the Royal Horticultural Society on 17 September 1889 and illustrated by Hogg (1889). However, the same acyanic clone was re-introduced into England by Robert Templeman in 1891. After attracting much attention at Kew Gardens, it was marketed in the 1890s by Wallace & Co. of Colchester as *W. iridifolia ardernei* (Watson 1896). It was recognised at the time (Watson 1896) that the epithets *ardernei* and *obrienii* referred to the same plant, and this was reconfirmed by Goldblatt (1989).

A potential conflict between the nomenclatural codes for cultivated and wild plants arose because Goldblatt (1989) published the combination *W. borbonica* subsp. *ardernei*, also based on *W. ardernei* Mathews & L.Bolus, for one of the wild variants of *W. borbonica*. Recognising that the name 'Ardernei' was not available for the acyanic cultivar, Mathew (1994) formally published the cultivar name 'Arderne's White' in conformity with the International Code of Nomenclature for Cultivated Plants (Brickell et al. 2004). However, his reference to this plant as "the white watsonia" glossed over the existence of other white-flowered cultivars derived from *W. borbonica*.

Watsonia alba Arderne is a synonym based on the same clone from Romans River (Goldblatt 1989). However, the name *W. alba* was already in horticultural use for at least one other white or almost-white watsonia cultivated in England and Australia before the Romans River plant was introduced. By 1871 the Adelaide Botanic Garden was growing a plant listed as '*Watsonia alba* Ker Gawl.' (Schomburgk 1871);

Table 4. Results of ammonia test for 15 acyanic *Watsonia* and 6 white or cream flowered species in other genera.

	colour reaction after 20 minutes in ammonia	colour reaction after a further 90 minutes in air
Controls		
<i>Argyranthemum frutescens</i> (L.)Sch. Bip.	bright clear yellow	fade to white
<i>Freesia alba</i> (Baker)Gumbl.	bright clear yellow	fade to white
<i>Gladiolus</i> 'Blushing Bride'	faint yellow-grey	fade to cream
<i>Iris albicans</i> Lange	bright clear yellow	fade to white
<i>Rosa banksiae</i> W.T. Aiton	bright clear yellow	fade to cream
<i>Spiraea cantoniensis</i> Lour.	bright clear yellow	fade to white
Acyanic <i>Watsonia</i>		
<i>W. borbonica</i> 'Arderne's White'	faint yellow-grey	fade to off-white
<i>W.</i> 'Ivory Towers'	faint yellow-grey	fade to off-white
accession 5	faint yellow-grey	fade to off-white
accession 17	faint yellow-grey	fade to off-white
accession 89	faint yellow-grey	fade to off-white
accession 91	faint yellow-grey	fade to off-white
acyanic progeny from cross 5	faint yellow-grey	fade to off-white
acyanic progeny from cross 6	faint yellow-grey	fade to off-white
acyanic progeny from cross 7	faint yellow-grey	fade to off-white
acyanic progeny from cross 8	faint yellow-grey	fade to off-white
acyanic progeny from cross 9	faint yellow-grey	fade to off-white
acyanic progeny from cross 11	faint yellow-grey	fade to off-white
acyanic progeny from cross 13	faint yellow-grey	fade to off-white
acyanic progeny from cross 14	faint yellow-grey	fade to off-white
acyanic progeny from cross 16	faint yellow-grey	fade to off-white

however, no valid publication of this name can be traced. It is unlikely to be a misprint for *W. roseoalba* (Jacq.) Ker Gawl., a pink and cream flowered species which has been reduced to synonymy under *W. humilis* Mill. by Goldblatt (1989), who also showed that it was based on *Gladiolus roseoalbus* Jacq. A white-flowered plant similar to *W. borbonica* grown at Thomas Ware's Hale Farm Nurseries in Tottenham, England, was also illustrated as *W. alba* (Anon 1880). Hogg (1884) at first described this flower as pure white, but O'Brien (quoted in Hogg 1889) later averred that his own introduction was the only pure white *Watsonia* and that all others, including by implication those known as *W. alba*, were pink tinged. It may be due to the confusion surrounding the epithet *alba* that Goldblatt (1989) chose *ardenei* as the epithet for the northern subspecies of *W. borbonica*.

The application of the names 'Alba' and 'O'Brienii' to white watsonias in early Australian nursery catalogues is uncertain; for example, Brunning (1905) offered two distinct cultivars under these names in the same catalogue. The uncertainty is compounded by the fact that the closely related species *W. versfeldii* Mathews & L. Bolus was not recognised as distinct from *W. borbonica* until 1922 (Goldblatt 1989). As an acyanic form of *W. versfeldii* has been found naturalised in Victoria (Cooke 1986), this may be the plant to which Brunning applied one or the other of these names.

'Arderne's White' reached the USA from Europe, and was used by Luther Burbank in a breeding program that produced several white cultivars including 'Royal White' and 'Vesta' between 1908 and 1917 (Howard 1945).

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Drosera hookeri R.P.Gibson, B.J.Conn & Conran, a replacement name for *Drosera foliosa* Hook.f. ex Planch., *nom. illeg.* (Droseraceae)

Robert P. Gibson^a, Barry J. Conn^b & John G. Conran^c

^aNorth East Branch – Hunter, Environment Regulation & Protection,
Department of Environment, Climate Change and Water, Newcastle, New South Wales 2300
E-mail: robert.gibson@environment.nsw.gov.au

^bNational Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust,
Mrs Macquaries Road, Sydney New South Wales 2000
E-mail: barry.conn@rbgsyd.nsw.gov.au

^cAustralian Centre for Evolutionary Biology & Biodiversity, Benham Building DX 650 312,
School of Earth & Environmental Sciences, The University of Adelaide, South Australia 5005
E-mail: john.conran@adelaide.edu.au

Abstract

Drosera hookeri R.P.Gibson, B.J.Conn & Conran (Droseraceae) is proposed as a replacement name for *Drosera foliosa* Hook.f. ex Planch., *nom. illeg.*, non Elliot (1821).

Keywords: Australia, *Drosera peltata* complex, *Drosera*, Droseraceae, nomenclature, taxonomy.

Introduction

Recent studies have shown that there are discrete taxa differing in growth habit, indumentum, sepal shape, petal colour and seed structure within the *D. peltata* complex (e.g. Pierson 1990; Gibson 1992a, 1992b, 1993). This has seen the reinstatement of *D. auriculata* Backh. ex Planch. in several treatments (e.g. Marchant *et al.* 1982; Harden 1990; Salmon 2001), the description of *Drosera bicolor* Lowrie & Carlquist (1992) and the resurrection of both *D. foliosa* Hook.f. ex Planch. and *D. gracilis* Planch. by Clayton (2003a, 2003b, 2005a, 2005b) and Morris (2009). However *D. foliosa* Hook.f. ex Planch., first published in 1848, is a later homonym for *D. foliosa* Elliott (1821), and so the Australian taxon needs to be renamed.

Drosera foliosa Hook.f. ex Planch. has usually been placed in synonymy under a very broadly circumscribed and variable *D. peltata* Thunb. (Marchant *et al.* 1982), within *D. peltata* subsp. *peltata* (Conn 1981) or sometimes as *D. peltata* var. *foliosa* Benth. (Bentham 1864).

Planchon (1848) cites the type of *D. foliosa* as ‘Hab. in insula Van Diemen loco dicto Formosa; Gunn, No. 1027 in Herb. Hook.’ There are two sheets of *D. foliosa* held at the herbarium of the Royal Botanic Gardens, Kew (K) labelled *Gunn 1027* (RBG Kew 2006–), one (Fig. 1) with three collection labels that read:

- ‘*D. foliosa* J.D.H. 1027/1842, Formosa, 7/12/42’ (K215054) – this material was collected from the W.E. Lawrence Estate ‘Formosa’ in the Midlands region of Tasmania (Buchanan 1988).
- ‘*Drosera foliosa* J.D.Hook., V[an] D[iemen’s] Land, Gunn, Tasmania, Fl. Tasmania, t. 6’ (K215071);

- ‘1027 George Town, both sides of River, 23/10/44’ (K215072) – included with this collection is the following note in R.C. Gunn’s hand: ‘1027. *Drosera foliosa* nsp. [new species][specific epithet ‘foliosa’ and ‘nsp’ in J.D. Hooker’s hand]. I saw this very abundantly at George Town on both sides of the Tamar [River] growing in rather marshy grassy spots. I at first thought it might have been a var. of my 448 [refer K215590, K215592–95], but I now feel satisfied that it is permanently [sic] distinct.’

The second sheet (refer RBG Kew 2006–) is a mixed collection, including one from *Herbarium Benthamianum* that reads: ‘1027 *Drosera foliosa* Hook. fil. Planch Ann. Sci. Nat. III. 9. 298, Tasmania. R. Gunn, 1844’ (accession K215073).

On the basis of Planchon’s (1848) reference to the type specimen, Conn (1981) considered that the 1842 Formosa collection represented the holotype, noting that the other *Gunn 1027* specimens would be syntypes. However, as *Gunn 1027* is a species identification reference, not a collection number (George 2009), the type would therefore be the one mentioned in Planchon’s (1848) protologue. Because this type collection consists of multiple specimens from a single gathering, we here designate one specimen as the lectotype (refer Figure 1), with the remainder of the gathering as isolectotypes (ICBN Art. 9.15). The other two *Gunn 1027* collections are either not from the type locality (K215072) or are not from Hooker’s Herbarium (K215073), and as they are not mentioned by Planchon (1848), it is here presumed that they were not seen by him. The type status of the remaining unnumbered *Gunn* collection (K215071) is more ambiguous, being without date

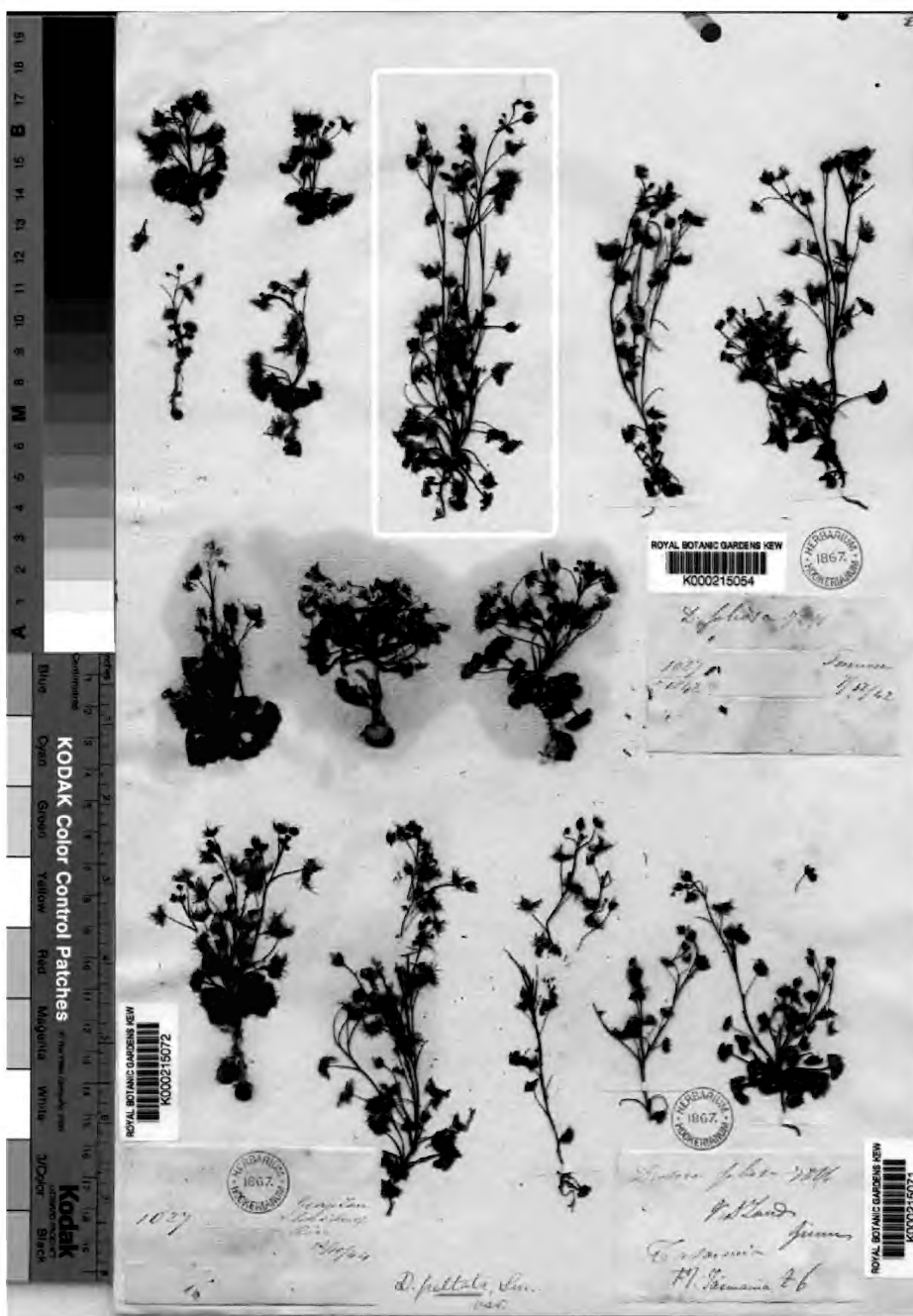


Fig. 1. *Drosera hookeri* type (accession identifier K215054, as *D. foliosa* Hook.f. ex Planch.) with lectotype (framed) and remainder of specimens of this accession isolectotypes (upper seven collections). Lower right four specimens (accession K215071) represent possible syntypes. The central three specimens and lower left specimen (possibly all accession K215072) are not regarded as type material. Image copyright of the Board of Trustees of the Royal Botanic Gardens, Kew, used with permission.

or specific location. It is here considered to represent possible syntype material. Additional R.C. Gunn collections of this taxon held at MEL and NSW, include: Van Diemensland, com[municated] Prof. Lindley, 1846 [all in John Lindley's hand], *Gunn*, ex Herbarium O.W. Sonder (MEL96616) and George Town, 16 Nov 1843, *Gunn 1027* (NSW146501). Neither collection is regarded as type material.

Examination of other possible names within the *D. peltata* complex reveals that apart from *D. peltata* and *D. auriculata* Backh. ex Planch. there are only two other available names for plants in this complex from Tasmania: *D. gracilis* Hook.f. ex Planch. and *D. peltata* var. [β] *gunniana* Planch. (Planchon 1848). However, *D. gracilis* is a separate taxon that occurs across south-east Australia (Gibson 1992b; Clayton 2003a, 2003b, 2005a, 2005b; Morris 2009), distinguished by a narrow stem which is normally leafless on the distal half and by its usually red foliage. Therefore, it is not available as a replacement name. Similarly, Hooker (1859) makes it clear that *D. peltata* var. *gunniana* is separate and clearly distinguishable from *D. foliosa* Hook.f. ex Planch. by being single-stemmed and less stout or shrubby, with researchers generally considering var. *gunniana* to be a localised Tasmanian form within *D. peltata* sens. str. (Conn 1981; Walker 2006–).

Since there is no available alternative name for *D. foliosa* Hook.f. ex Planch., a new epithet for this taxon is required if it is to be recognised. Both R.C. Gunn and J.D. Hooker recognised this taxon as distinct (refer handwritten note accompanying K215072, see above). Accordingly, *D. hookeri* R.P.Gibson, B.J.Conn & Conran is proposed here as the replacement name. The new epithet commemorates Joseph Dalton Hooker (1817–1911) who originally recognised this taxon and provided a manuscript name which was used by J.E. Planchon (1848).

***Drosera hookeri* R.P.Gibson, B.J.Conn & Conran,
nom. nov.**

Drosera foliosa Hook.f. ex Planch., Ann. Sci. Nat. sér 3, 9: 298 (1848), nom. illeg., non *Drosera foliosa* Elliott, Sketch Bot. S. Carolina 1: 376 (1821). *Drosera peltata* Thunb. var. *foliosa* (Hook.f. [ex Planch.]) Benth., Fl. Austral. 2: 465 (1864). — **Lectotype (here selected):** Formosa, Tasmania, 7 Dec. 1842, *R.C.Gunn 1027* (K215054, top row, middle specimen; as indicated in Fig. 1). **Isolectotype:** remaining specimens of K215054. **Possible syntype:** V[an] D[iemen's] Land, *Gunn s.n.*, Tasmania (K215071).

Drosera peltata auct. non Thunb.: Marchant, Fl. S. Austral. 1: 363 (1986), partly.

Drosera peltata auct. non Thunb. subsp. *peltata*: Marchant et al., Fl. Austral. 8: 22–24 (1982), partly.

Drosera hookeri has generally villous to pubescent calyces, or at least fringed sepal margins, as found in *D. gracilis*, *D. peltata* and *D. bicolor*. *Drosera hookeri* is also similar to *D. peltata* except that the former is a multi-branched herb, whereas the stems of *D. bicolor* and *D. peltata* are usually unbranched or have only

a few branches distally. It is also a more robust plant than *D. gracilis*, with stems about 1–2 mm in diameter, whereas those of *D. gracilis* are up to about 0.5 mm diameter.

Distribution and ecology. All species discussed here, except for *D. gracilis*, occur in seasonally-moist infertile mineral-based soils. *Drosera hookeri* usually occurs in herbfields and low open shrublands from southern inland New South Wales to central Victoria and west to southern South Australia. It also occurs in north-eastern Tasmania. *Drosera peltata* grows in woodlands and open forests and occurs widely from southern Tasmania to the Darling Downs in Queensland, extending inland through western New South Wales to south eastern South Australia. It also occurs in New Zealand (Salmon, 2001). The *D. peltata* 'Western Australian Form' *sensu* Lowrie (1987) occurs amongst granite outcrops in southern inland Western Australia. *Drosera bicolor* occurs in deep sandy soil in open low *Banksia* woodland just west of Lake Chidnap in southern inland Western Australia. *Drosera gracilis* usually grows in peaty soils that are permanently rather than seasonally wet and it occurs in wetlands of the coast and ranges from north-eastern NSW to Tasmania.

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A new species of *Euphorbia* subgenus *Chamaesyce* Raf. (Euphorbiaceae) from the Flinders Ranges, South Australia

D.A. Halford & W.K. Harris

c/- Queensland Herbarium, Department of Environment and Resource Management,
Brisbane Botanic Gardens Mt Coot-tha, Mt Coot-tha road, Toowong, Queensland 4068

Abstract

Euphorbia flindersica Halford & W.K.Harris, endemic to the Flinders Ranges, South Australia, is described, illustrated and diagnosed. It was previously recognised as *Chamaesyce* sp. *Papillose plants* (D.E.Symon 14628). The taxon known by the phrase name *Chamaesyce* sp. *Marree* (F.J.Badman 776) is conspecific with *Euphorbia inappendiculata* var. *queenslandica* Domin.

Keywords: Euphorbiaceae, *Euphorbia* subgenus *Chamaesyce*, nomenclature, taxonomy, new species.

Introduction

The authors are nearing the completion of a review of the taxonomy and nomenclature of *Euphorbia* subgenus *Chamaesyce* Raf.¹ in Australia prior to the finalization of the treatment of the Australian species for the *Flora of Australia*. We were recently asked by the author preparing the treatment of *Euphorbia* for the forthcoming new edition of *Flora of South Australia* for our evaluation of the taxa recognized in South Australia under the phrase names *Chamaesyce* sp. *Marree* (F.J. Badman 776) R.M.Barker and *Chamaesyce* sp. *Papillose plants* (D.E.Symon 14628) W.R.Barker (Barker et al. 2005).

Chamaesyce sp. *Papillose plants* (D.E.Symon 14628) herein named *Euphorbia flindersica*, is confined to the Flinders Ranges, South Australia. The first collection of this species was by Robert Brown from the Spencer Gulf region in 1802. Bentham (1873) in his treatment of *Euphorbia* in *Flora Australiensis* cites this specimen ("Spencer's Gulf, R. Brown") under *E. drummondii* Boiss.

Chamaesyce sp. *Marree* (F.J.Badman 776), first recognised in South Australia as *Euphorbia* "Marree" (F.J.Badman 776) W.R.Barker (Jessop 1993), is representative of a species which is widespread through central Australia. The species has also been informally recognized under other phrase names in other States and regional floras (*Chamaesyce* sp. *B.*: James & Harden 1990; *Euphorbia* sp. *Clay soil* (C.Materne 04/07/2000): Albrecht et al. 2007; Northern Territory Government 2007). Our studies have shown it to be conspecific with *Euphorbia inappendiculata* var. *queenslandica* Domin,

a name not used since its publication by Domin in 1927. Domin's name for this taxon should be adopted.

The new species, *Euphorbia flindersica*, is compared to *E. drummondii* in the diagnosis because this is the species that the majority of specimens have been identified as prior to the application of the phrase name. The name *E. drummondii* has been applied in a very broad sense in the past and has included what we believe to be a number of undescribed distinct taxa. These will be described in the forthcoming review and their similarities and differences to *Euphorbia flindersica* will be discussed.

Unless otherwise stated ('n.v.' after the Herbarium acronym), all specimens cited in this paper have been seen by at least one of the authors. Leaf and fruit surfaces need to be examined at 20 to 40 times magnification to assess whether the surfaces are smooth or papillose.

Taxonomy

Euphorbia flindersica Halford & W.K.Harris, sp. nov.

Cum *E. drummondii* Boiss. quondam confusa, autem foliis fructibusque papillosis (vice laevis in *E. drummondii*), glandibus involucribus planis vel leviter concavis (vice profunde concavis in *E. drummondii*), appendicibus glandis grandioribus conspicuisque dentatis vel lobatis irregulariter (0.3–0.4 mm longis vice usque 0.1 mm longis in *E. drummondii*), stylis divisis, bifidis per 1/4–1/3 longitudinis (vice integris vel vix bifidis in *E. drummondii*), foliis comparate brevioribus, 1.5–1.8-plo longioribus quam latitudine (vice 1.7–5-plo longioribus quam latitudine in *E. drummondii*) distinguenda.

Typus: South Australia, Flinders Ranges region. Mt Gee, 15 Sept. 1973, R.H.Kuchel 3169; holo: AD 97346142.

Euphorbia drummondii auct. non Boiss.: Bentham, Fl. Austral. 6: 49 (1873), pro parte; J.Z.Weber in Jessop & Toelken, Fl. S. Austral. 2: 748 (1986), pro parte.

¹ EDITORIAL NOTE: This paper follows the recent adoption of *Euphorbia* L. rather than *Chamaesyce* Gray by the Australian Plant Census, based on molecular evidence (Park & Elisens 2000; Steinmann & Porter 2002; Bruyns et al. 2006). See also <http://www.euphorbiaceae.org/> [accessed: 6 Sep 2010].

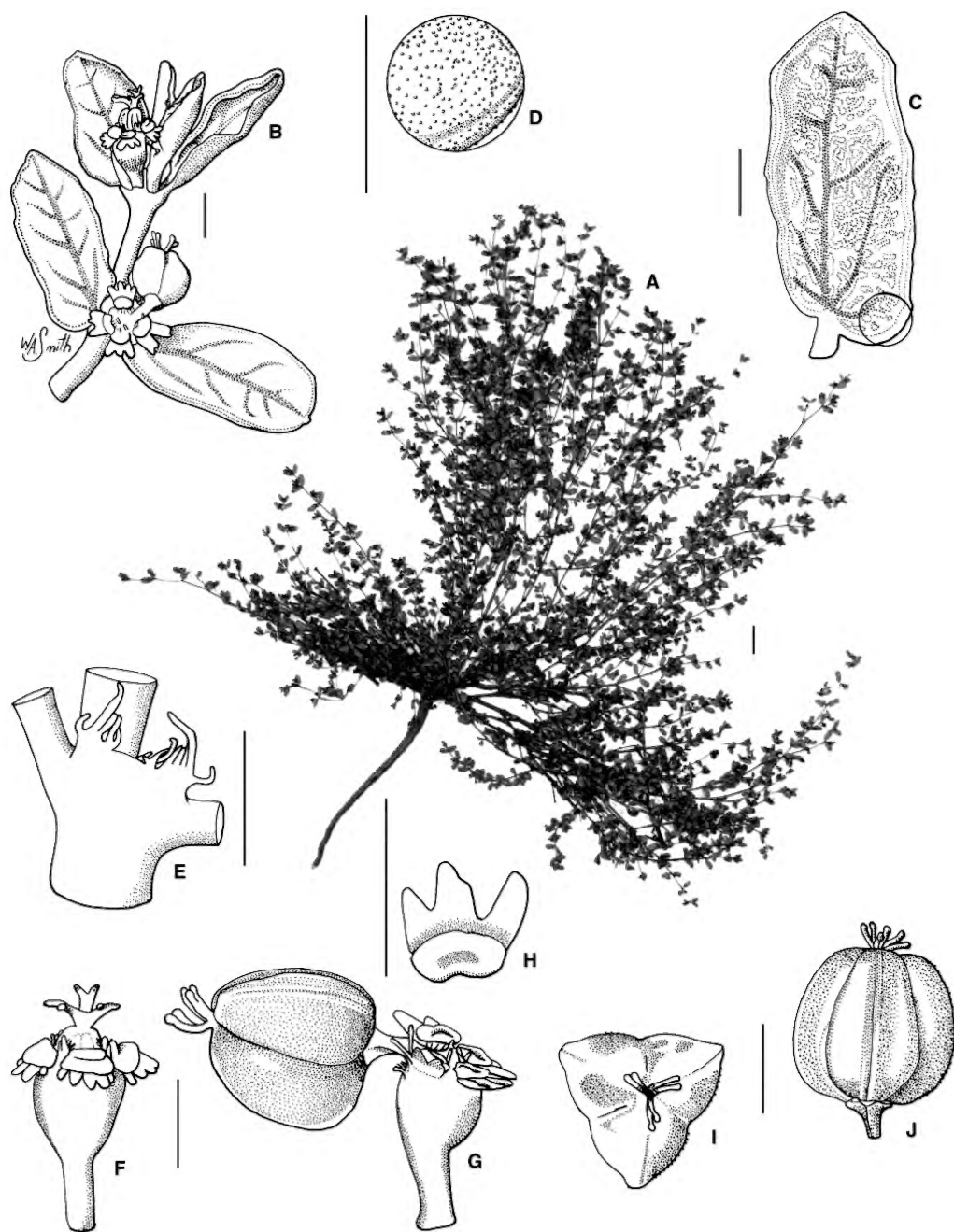


Fig. 1. *Euphorbia flindersica*. A habit; B branchlet with flowers and fruit; C leaf; D papillose lower leaf surface; E stipules; F cyathia; G cyathia with fruit; H involucral gland with appendage; I fruit (top view), with minute papillae; J fruit (side view), with minute papillae. Scale bars: A 1 cm; B–J 1 mm. — A–E, H–J R.H.Kuchel 3169; F, G D.J.E. Whibley 3922.

Euphorbia inappendiculata auct. non Domin: J.Z.Weber in Jessop & Toelken, Fl. S. Austral. 2: 750 (1986), pro parte.

Chamaesyce sp. *Papillose plants* (D.E.Symon 14628) R.M.Barker, J. Adelaide Bot. Gard. Suppl. 1: 84 (2005). — *Euphorbia* sp. *Papillose plants* (D.E.Symon 1428) R.M.Barker, Austral. Pl. Cens. <http://www.anbg.gov.au/chah/apc/> [accessed 6 Sep. 2010].

Herbaceous perennial to 10 cm high, much branched from the base with short-lived stems produced from thick somewhat woody rootstock. Stems prostrate to erect, mostly red or pinkish in colour, smooth or faintly papillose, glabrous. Interpetiolar stipules deeply bipartite, 0.4–0.6 mm long, glabrous; lobes triangular, margins entire or laciniate. Leaves discolorous; petiole 0.2–1.2 mm long, smooth, glabrous; blade oblong or obovate, 1.3–6.7 mm long, 1.0–3.8 mm wide, 1.5–1.8 times longer than wide, minutely papillose (viewed at 40× mag.), glabrous, mostly green above sometimes with reddish colour on margin, paler below, base strongly asymmetric with a cordate to rounded side and a cuneate to rounded side, margins entire or sparsely minutely toothed distally, apex rounded. Cyathia axillary, solitary; peduncles 0.3–0.7 mm long, smooth, glabrous. Involucres campanulate or cupuliform, 0.8–1 mm long, 0.6–1.2 mm across, glabrous outside, hairy inside below glands; lobes 5, triangular, 0.3–0.4 mm long, ciliate on margins; glands 4, red or yellowish green, patelliform, transverse-oblong to transverse-elliptic, 0.1–0.3 mm long, 0.3–0.5 mm wide, appendages conspicuous, pink or red, spreading, obdeltoid, 0.3–0.4 mm long, 0.6–0.8 mm wide, dentate or irregularly lobed. Male flowers 10–15 per cyathium; pedicel 0.7–1.0 mm long; staminal filaments c. 0.1 mm long. Female flowers: pedicel c. 0.3 mm long in flower, 1.5–2.7 mm long in fruit, smooth, glabrous; ovary papillose, glabrous; styles 3, c. 0.5 mm long, spreading, smooth, glabrous, bifid to 1/4–1/3 of their length. Capsules shallowly 3-lobate, ovate or broad-ovate in lateral view, 1.5–1.8 mm long, 1.7–2.2 mm across, papillose, glabrous. Seeds obovate in outline, 1.1–1.3 mm long, 0.7–0.8 mm wide, 0.6–0.8 mm thick, 4-angled in cross section, cream or pale brown, smooth or obscurely irregularly rugulose. Fig. 1.

Phenology. Flowers and fruits have been collected from April to October.

Distribution and habitat. *Euphorbia flindersica* is endemic in South Australia, where it is restricted to the northern Flinders Ranges, occurring from near Leigh Creek to Hawker. The species grows in sandy clay soils among rocky outcrops and on gravelly hill slopes.

Affinities. *Euphorbia flindersica* has been confused with *E. drummondii* Boiss. in the past but can be distinguished by its papillose leaves and fruit (smooth in *E. drummondii*), flat or shallowly concave involucre glands (deeply concave in *E. drummondii*), larger and conspicuous gland appendages 0.3–0.4 mm long which are dentate or irregularly lobed (0.1 mm long

and entire in *E. drummondii*), divided styles (bifid to 1/4–1/3 of their length versus entire or scarcely bifid in *E. drummondii*) and relatively wider leaves (1.5 to 1.8 times as long as wide versus 1.7 to 5 times as long as wide in *E. drummondii*).

Euphorbia flindersica will key to *E. inappendiculata* Domin in Weber's (1986) key to *Euphorbia* in the *Flora of South Australia*. The name *E. inappendiculata* has been misapplied in Weber's treatment. His concept includes the species here referred to *E. flindersica* as well as a species correctly referred to *Euphorbia ferdinandi* Baill. *Euphorbia ferdinandi* is widespread in arid Australia extending from near Wiluna and Laverton, Western Australia, east through the Northern Territory and South Australia to western Queensland and north-western New South Wales. *Euphorbia flindersica* can be distinguished from *E. inappendiculata* by its flat or shallowly concave involucre glands (deeply concave in *E. ferdinandi*), larger and conspicuous gland appendages 0.3–0.4 mm long which are dentate or irregularly lobed (0.1 mm long and entire or absent in *E. ferdinandi*) and divided styles (bifid to 1/4–1/3 of their length versus entire or scarcely bifid in *E. ferdinandi*).

Etymology. The specific epithet *flindersica* refers to the Flinders Ranges, South Australia, to which this species is confined.

Representative specimens (22 examined)

SOUTH AUSTRALIA. Nepouie Springs, 26 Apr. 1994, R.Bates 37341 (AD); Mawson Plateau, Flinders Ranges, 24 Apr. 1996, R.Bates 43040 (AD); hill on N side of Nent Oura Research Unit, Mount Freeling Station, 17 Sep. 1987, G.H.Bell 1325 (AD); Inlet XII [Spencers Gulf], [10 Mar. 1802], R.Brown (K); Paralana Springs, 125 km NE of Blinman, 24 Aug. 1968, J.Carrick 2059 (AD, COLO n.v.); Italoowie Creek, Aug. 1979, P.E.Conrick AD100 (AD); Chambers Gorge, near Mt Chambers, c. 60 km ENE of Blinman, 12 Sep. 1956, Hj.Eichler 12559 (AD, K n.v., L n.v.); The Bunkers, foothills and slopes of the Bunkers Range, 18 Apr. 1989, E.M.James 16 (AD); upper Bunyerroo Gorge, c. 50 km NNE of Hawker, 4 Oct. 1958, D.Kraehenbuehl 14 (AD); Arkaroola Sanctuary, Ridge Top road, 20 Oct. 1971, R.H.Kuchel 3039 (AD); Gorge creek of Myrtle Springs, c. 24 km NW of Leigh Creek, 29 Sep. 1962, T.R.N.Lothian 1077 (AD); Parachilna Gorge, 31 Aug. 1963, M.C.R.Sharrad 1404 (AD); Moralana Station, road & rail-crossing Bunyerroo Creek, 10 Jul 1987, D.E.Symon 14628 (AD); Brachina Gorge, 7 Sep. 1961, D.E.Symon 1400 (AD); Oraparinna National Park, western portion, 20 Sep. 1971, J.Z.Weber 2710 (AD); Chambers Gorge, c. 80 km ENE of Parachilna, 12 Sep. 1973, D.J.E.Whibley 3922 (AD); Balcanoona Station, Grindell Hut, 19 Jul. 1980, L.D.Williams 11205 (AD).

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Taxonomic notes on South Australian *Ptilotus* (Amaranthaceae)

T.R. Lally^a & W.R. Barker^{b, c}

^a Australian National Herbarium, Centre for Plant Biodiversity Research,
GPO Box 1600, Canberra, Australian Capital Territory 2601
E-mail: Terena.Lally@csiro.au

^b State Herbarium of South Australia, P.O. Box 2732, Kent Town, South Australia 5071
E-mail: bill.barker@sa.gov.au

^c Australian Centre for Evolutionary Biology & Biodiversity, The University of Adelaide, South Australia 5005

Abstract

Taxonomic and nomenclatural changes to three *Ptilotus* taxa are presented in advance of the revised edition of the *Flora of South Australia*. *Ptilotus gaudichaudii* (Steud.) J.M.Black is now considered to comprise three subspecies: *P. gaudichaudii* subsp. *gaudichaudii*, *P. gaudichaudii* subsp. *eremita* (S.Moore) Lally, *comb. et stat. nov.* and *P. gaudichaudii* subsp. *parviflorus* (Benth.) Lally, *comb. et stat. nov.* A further subspecies is recognised in *P. nobilis* (Lindl.) F.Muell.: *P. nobilis* subsp. *angustifolius* (Benl) Lally & W.R.Barker, *comb. et stat. nov.* and its geographical range is clarified. *Ptilotus nobilis* var. *pallidus* Benl is reduced to a synonym of *P. nobilis* subsp. *nobilis*. *Ptilotus spathulatus* f. *angustatus* Benl is also reduced to synonymy under *P. spathulatus* (R.Br.) Poir. Keys to infraspecific taxa in *P. gaudichaudii* and *P. nobilis* are presented.

Key words: Amaranthaceae, *Ptilotus*, taxonomy, nomenclature, South Australia.

Introduction

In preparing a treatment of the genus *Ptilotus* for the new edition of the *Flora of South Australia*, a number of taxonomic issues requiring resolution were identified by the first author. Independently of this research, studies by W.R. Barker revealed further taxonomic issues within *Ptilotus nobilis*. The opportunity is taken here to present, in part, the outcomes of this research in advance of the new State *Flora*.

Materials and methods

This study is based on examination of herbarium specimens from AD, BM, CANB, G-DC, K, M, MEL and P. Measurements were made from fresh specimens and herbarium material (rehydrated where required).

Terminology used here to describe the hairs follows that of Benl (1971), as translated by Burbidge (1972). The hairs are basically of the same type (simple) but vary in the degree to which lateral projections are produced at the septa between the primary cells. The leaves of taxa described here superficially appear petiolate, but are here treated as sessile. The leaf lamina extends and narrows to the leaf base, with no discernable petiole.

Benl commonly used the ranks of variety and forma to classify infraspecific variation. In more recent times subspecific rank has been utilised (Bean 2008) for eastern Australian *Ptilotus*. The first author has chosen to continue with this approach for her progressive revision of the genus.

Taxonomy

1. *Ptilotus gaudichaudii*

As indicated by Bean (2008), morphological differences are apparent between the two existing varieties in this species. Further study has revealed there are three infraspecific taxa sufficiently distinct to be recognised at subspecies rank.

Ptilotus gaudichaudii (Steud.) J.M.Black

Trans. & Proc. Roy. Soc. S. Australia 69: 309 (1945).
— *Trichinium gaudichaudii* Steud., Nom. Bot. ed. 2, 2: 700 (1841). — *T. corymbosum* Gaudich. in H.L.C. de S.Freycinet, Voy. Uranie Bot. 444 (1829), nom. illeg. —
Type: Western Australia: Shark Bay, *C. Gaudichaud s.n.* (holo: P 00609973).

Trichinium corymbosum 'β' Nees in J.G.C. Lehmann, Pl. Preiss. 1: 630 (1845). — *T. corymbosum* var. *ramosum* Nees ex Moq. in A.P. de Candolle, Prodr. 13: 292 (1849).
— **Type:** Western Australia: near Marrell's farm, York, 30 Mar. 1840, *L. Preiss 1368* (holo: LD 1214295, n.v., digital image at CANB).

Annual or perennial *herb* to 70 cm high; stems ribbed, with very sparse, long, weak, simple or ± nodose, sometimes twisted or crisped hairs, denser on newer growth, becoming glabrescent or glabrous. *Leaves* sessile, narrowly obovate or narrowly elliptic, rarely subspathulate or ovate, 5–47 (–65) mm long, including the long attenuate bases of the basal leaves, 0.5–5 (–8) mm wide, hairs as for stems, basal leaves often curled and senescent by anthesis; apices with mucro to 0.8 mm long. *Inflorescence* globular or oblong,

rarely hemispherical spikes, rachis to 3 cm long, 8–35 flowered. Bract and bracteoles usually glabrous, or with long, sparse, simple hairs on or near midrib, both with a fleshy herbaceous pad at base, remainder hyaline, golden-brown; apices apiculate, the *bract* 2.7–5 mm long, *bracteoles* 3–5.4 mm long. *Perianth* 7.5–15 mm long, green with broad white margins, aging to yellow; *tepals* narrowly ovate, slightly concave, geniculate above bulbous base, outer tepals marginally longer than inner; outer surface with dense, nodose hairs to 3.5 mm long on bulbous base, remainder of tepal with sparse to moderately dense, nodose hairs to 2 mm long, attached to midrib, forming two comb-like rows; margins scarious, glabrous, apices acute; inner surface of outer tepals glabrous; inner surface of inner tepals with moderately dense, crisped, nodose hairs, attached to the margins on lower quarter, hairs extending to a third tepal length. Fertile *stamens* 3 or 4, filaments 2–10 mm long, deep red, purple or cream; *anthers* 0.4–1.8 mm long; *staminodes* 1 or 2, approximately half fertile stamen length. *Ovary* with few to many nodose hairs at apex, sometimes glabrous; *style* eccentric, 2–10.5 mm long, sometimes sinuous.

Key to subspecies of *Ptilotus gaudichaudii*

1. *Perianth* 10–15 mm long; *style* 7–10.5 mm long subsp. *gaudichaudii*
- 1: *Perianth* 6–9 mm long; *style* 2–5 mm long
 2. Fertile staminal filaments 4–5 mm long, deep red to purple; *style* 4–5.3 mm long; central and eastern Australia subsp. *parviflorus*
 - 2: Fertile staminal filaments 2–3 mm long, cream; *style* 2–2.5 mm long; Western Australia subsp. *eremita*

Ptilotus gaudichaudii (Steud.) J.M.Black subsp. *gaudichaudii*

Illustration. P.Moore, Guide Pl. Inland Australia 256 (2005).

Bract 4–5 mm long; *bracteoles* 4.5–5.2 mm long. *Perianth* 10–15 mm long. *Staminal* filaments 8.5–10 mm long, cream, sometimes deep red or with pale purple or red streaks. *Style* 7–10.5 mm long.

Distribution & notes. Occurs from the west coast of Western Australia, between Perth and Shark Bay, eastwards to Alice Springs in southern Northern Territory and south to the northern part of the Eyre Peninsula in South Australia. It grows on dunes, plains or creek banks, in red or brown sand, loam or clay-loam, in open mulga (*Acacia aneura*) woodland, chenopod shrubland or *Triodia* communities.

Ptilotus gaudichaudii subsp. *gaudichaudii* is distinguished from subsp. *eremita* and subsp. *parviflorus* by its longer perianths and correspondingly larger inflorescences (to 3 cm long × 3 cm wide), longer stamens and style, and, frequently larger, more robust habit.

Representative specimens examined

WESTERN AUSTRALIA. 21 km NW of Ashburton Downs on the Kooline road, 9 Sept. 1986, R.J.Chinnock 7049 (AD,

CANB); 2.5 km S of Binnu on Brand Highway, 23 Oct. 2000, B.J.Lepschi 4329 & L.A.Craven (AD, CANB, L, PERTH, US, W); 18 miles [28.8 km] E of Pindar, 10 Oct. 1945, R.D.Royce 670 (CANB, PERTH).

NORTHERN TERRITORY. Katadjuta [Kata Tjuta], The Olgas, 30 May 1985, R.Bates 5600 (AD, CANB); Andado Station, Wilyunpa Tableland, 18 Apr. 1977, T.S.Henshall 1492 (AD, CANB, DNA, MEL); 10 miles [c. 16 km] SW of Alice Springs, 9 May 1972, P.K.Latz 2486 (CANB, DNA).

SOUTH AUSTRALIA. 32 km N of Marla Bore, 14 July 1982, P.E.Corrick 763 (AD, CANB); Durkin Outstation, which is ca 15 km W of Mulgathing, 26 Sept. 1971, J.Z.Weber 2798 (AD, CANB, CHR, G).

Ptilotus gaudichaudii subsp. *eremita* (S.Moore) Lally, *comb. et stat. nov.*

Trichinium eremita S.Moore, J. Linn Soc., Bot. 34: 218 (1899). — **Type:** Western Australia: ‘Ad Gibraltar florebat mens. Sept.’ [goldfields near Gibraltar], Sept. 1895, S.Moore s.n. (holo: BM 000895588, n.v., digital image at CANB; iso: K 000356905, n.v., digital image at CANB, NY n.v.).

Bract 3–4.5 mm long; *bracteoles* 3.5–5 mm long. *Perianth* 6.6–8.5 mm long. *Staminal* filaments 2–3 mm long, cream. *Style* 2–2.5 mm long.

Distribution & notes. Occurs in Western Australia between Shark Bay and Kalgoorlie. It occurs in dune country, or on hillslopes or outcrops, with soils of red brown or yellow sand or clay, sometimes overlying laterite. It grows in open eucalypt woodland or tall shrubland with *Acacia*, *Dodonaea* and *Melaleuca*.

Ptilotus gaudichaudii subsp. *eremita*, has previously been included within the similar *P. gaudichaudii* subsp. *parviflorus*. It differs from this subsp. by its short, cream-coloured staminal filaments, and the short style. From *P. gaudichaudii* subsp. *gaudichaudii* it differs by its usually more delicate habit, with a smaller inflorescence (to 2 cm long × 2 cm wide) and smaller sized perianths. Although its distribution overlaps with that of subsp. *gaudichaudii*, this taxon is easily distinguished by its very short staminal filaments and style. The style of subsp. *gaudichaudii* is 7.5–10.5 mm long, and usually easily visible near the perianth apex at anthesis, whereas in subsp. *eremita* the style is shorter (2–2.5 mm long) and enclosed in the perianth at anthesis.

Representative specimens examined

WESTERN AUSTRALIA. Meckering, 5 Oct. 1977, G.Benl Au 10 & A.S.George (CANB, M); 3.2 km E of Laurances Find, Walling Rock Station, 14 Sep. 1988, R.J.Cranfield 7419 (CANB, PERTH); 0.8 km W of homestead, Dirk Hartog Island, 3 Sep. 1972, A.S.George 11421 (CANB, PERTH); Cowcowing, Sep. 1904, M.Koch 1613 (MEL); 200 km NE of Geraldton and 44 km S of Murgoo Homestead, 3 Sep. 1970, P.G.Wilson 9940 (CANB, PERTH).

Ptilotus gaudichaudii subsp. *parviflorus* (Benth.)

Lally, *comb. et stat. nov.*

Trichinium corymbosum var. *parviflorum* Benth., Fl. Austral. 5: 226 (1870). — *Hemisteirus psilotrichoides* F.Muell., Linnaea 25: 435 (1852). — *Ptilotus hemisteirus* F.Muell., Fragm. 4: 90 (1864), nom. illeg. — *Ptilotus*

gaudichaudii var. *parviflorus* (Benth.) Benl. Mitt. Staatssamml. Bot. München 3: 36 (1959). — **Type:** South Australia: Cudnaka, Oct. 1851, *F.Mueller s.n.* (holo: MEL, n.v., *fide* A.R.Bean, pers. comm.).

Illustration. S.W.L.Jacobs & L.Lapinuro in G.J.Harden (ed.), Fl. N.S.W. 1: 259 (1990).

Bract 2.7–4.2 mm long; *bracteoles* 3–5.4 mm long. *Perianth* 7.5–9 mm long. *Staminal* filaments 4.5–5 mm long, deep red or purple. *Style* 4–5.3 mm long.

Distribution & notes. Occurs in southern Northern Territory near Alice Springs, in south-west Queensland, southwards through western New South Wales, and into eastern South Australia in the southern Flinders Ranges and adjacent area south of Barrier Highway. The subspecies grows on flats or low rises in red sand, loam or clay-loam, sometimes with stones or gravel particles, growing in open eucalypt and mulga (*Acacia aneura*) woodland or shrubland, grassland or herbfields.

This subspecies shares a similar delicate habit, small inflorescences and small perianths with subsp. *eremita*, but is readily distinguished from that taxon by its longer, deep red to purple staminal filaments, and longer style. It differs from subsp. *gaudichaudii* in its smaller perianths with shorter stamens and style.

Representative specimens examined

NORTHERN TERRITORY. North Bond Gap, Simpsons Gap National Park, 24 Aug. 1995, *D.E.Albrecht 6833 & P.K.Latz* (NT); 17 miles [27 km] N of Alice Springs, 19 Nov. 1968, *D.J.Nelson 1786* (AD, NT); 2 miles [3 km] S of Kunoth Well, Hamilton Downs, 27 Sept 1973, *D.J.Nelson 2318* (NT).

SOUTH AUSTRALIA. Next to the Weekeroo – Plumbago Road, just opposite dam at Weekeroo Springs, 30 July 1989, *R.J.Bates 19954* (AD); Bimbowrie Station, 2 Oct. 1995, *R.J.Bates 41228* (AD); Oakbank Station, 20 Sept. 1968, *J.B.Cleland s.n.* (AD97308290); Danggali Conservation Park, 100 m along track to NW – 5 km N of turn off to Mulga Dam, 3 Mar. 1993, *D.D.Cunningham & B.R.Moore 613* (AD).

QUEENSLAND. 7 km W of 'Tomoo', SW of Mitchell, 11 Sept. 2005, *A.R.Bean 24370* (BRI, CANB, MEL, NSW); 5 km from Adavale towards Blackall, 25 Oct. 1983, *E.M.Canning 6214* (BRI, CANB); Dundee Station, 20 Mar. 1947, *S.L.Everest 2749* (BRI, CANB).

NEW SOUTH WALES. 40 km NNW of Cobar, Bundella Station W boundary, 1.9 km SSE of Joe's Tank, 7 Sept. 1978, *M.D.Crisp 4152* (CANB, NSW); Roto, S of railway, 8 Oct. 2000, *K.D.Hill 5528 et al.* (CANB, MEL, NSW); Road between Trida and Keewong, c. 36.5 km N from turnoff along road between Matakana and Ivanhoe, 19 Apr. 2003, *R.W.Purdie 5653* (CANB, NSW).

2. *Ptilotus nobilis*

Ptilotus nobilis (Lindl.) F.Muell. (including *P. exaltatus* Nees) is a widespread and variable taxon which has been treated for eastern Australia by Lee *et al.* (2007) and Bean (2008). Two subspecies are presently recognised, *P. nobilis* subsp. *nobilis* and *P. nobilis* subsp. *semilanatus* (Lindl.) A.R.Bean, but further variation exists in populations in South Australia, the Northern Territory and Western Australia. Additional infraspecific taxa, originally described under *P. exaltatus*, require

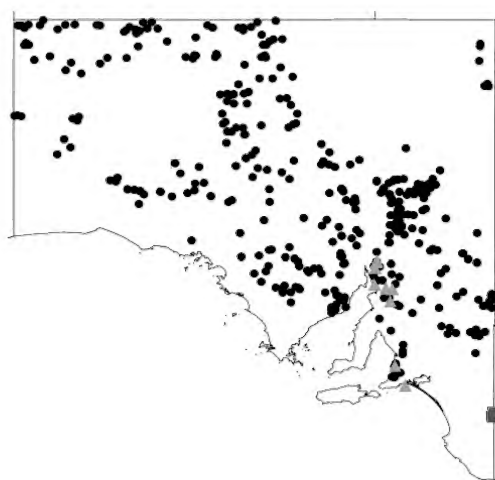


Fig. 1. Distribution of *Ptilotus nobilis* in South Australia: subsp. *nobilis* (black circles); subsp. *angustifolius* (light grey triangles); subsp. *semilanatus* (grey squares).

further assessment, particularly in Western Australia. For the purposes of this paper, only taxa recorded for South Australia are considered. Synonymy and typification largely follow Bean (2008).

Key to subspecies of *Ptilotus nobilis* in S.A.

1. Basal leaves 16–34 mm wide, attenuate leaf bases < one third the length of the lamina; inflorescences usually cylindrical, rarely ovoid subsp. *nobilis*
- 1: Basal leaves 1–15 mm wide, attenuate leaf bases > half the length of the lamina; inflorescences usually hemispherical or ovoid, rarely cylindrical
2. Perianth 21–27 mm long; style > 15 mm long; southern South Australia subsp. *angustifolius*
- 2: Perianth 13–22 mm long; style < 15 mm long; eastern South Australia, Victoria, New South Wales and Queensland subsp. *semilanatus*

Ptilotus nobilis (Lindl.) F.Muell. subsp. *nobilis*

Trichinium nobile Lindl. in T.Mitch., Three Exped. Australia 2: 23 (1838). — **Type:** New South Wales: Interior of New Holland, 2 Apr. 1836, *T.L.Mitchell 50* (holo: CGE, n.v.).

Ptilotus exaltatus Nees in Lehm., Pl. Preiss. 1: 630 (1845). — *Trichinium exaltatum* (Nees) Benth., Fl. Austral. 5: 224–5 (1870). — *Ptilotus exaltatus* Nees var. *exaltatus*, Census N.S.W. Pl. 72 (1916). — **Type:** Western Australia: Avon River, between the farms of Messrs Heals and Whitfield, Mar. 1840, *L.Preiss 1367* (holo: LD, n.v.).

Trichinium densum A.Cunn. ex Moq. in A.DC., Prodr. 13: 289 (1849). — **Type:** New South Wales: Swampy-plains near Lachlan River, June 1817, *A.Cunningham s.n.* (holo: G-DC; iso: CGE, both n.v.).

Trichinium burtonii F.M.Bailey, Bull. Dept. Agric. Queensland 7: 14 (1891). — **Type:** Queensland: Between Camooweal and Urundangi towards Georgina R., 1890, *R.C.Burton s.n.* (holo: BRI; iso: MEL, both n.v.).

Trichinium nervosum F.M.Bailey, Queensland Agric. J. 25: 287 (1910). — **Type:** Queensland: Georgina River, Sept.



Fig. 2. Isotype of *Philotus nobilis* subsp. *angustifolius* (Benl) T.R.Lally & W.R.Barker (NSW 29534). Specimen image supplied by the National Herbarium of New South Wales, Botanic Gardens Trust, Sydney.

1910, *E.W.Bick* 51 (syn: BRI, n.v.); ditto, *E.W.Bick* 50 (syn: BRI, n.v.).

Ptilotus exaltatus Nees var. *pallidus* Benl, Mitt. Staatssamml. Bot. München 15: 164 (1979), **syn. nov.** — **Type:** Northern Territory: Mt Olga, *B.Barlow* 1877 (holo: AD 97733105).

Illustrations. G.Benl in J.P.Jessop & H.R.Toelken (eds), Fl. S. Austral. ed. 4, 1: 329, fig. 186A–B (1986); N.G.Walsh in N.G.Walsh & T.J.Entwistle (eds), Fl. Victoria 3: 211, fig. 37e–f, o–p (1996), as *P. exaltatus*; P.Moore, Guide Pl. Inland Austral. 255 (2005), as *P. exaltatus*.

Distribution & notes. Widespread throughout Western Australia, the Northern Territory, South Australia, south-western Queensland, western New South Wales and north-western Victoria (Fig. 1). Grows on sometimes skeletal or stony, red loams or sands and brown clays, on plains, dunes or slopes, associated with *Acacia* or mallee-eucalypt woodland or shrubland, *Spinifex* grassland, or ephemeral herbfields.

Benl (1979) distinguished *P. exaltatus* var. *pallidus* by its larger, pallid bract and bracteoles and relatively shorter hemispherical-rounded inflorescences. Whilst this combination of characters is uncommon it is considered to be within the range of variation for *P. nobilis* subsp. *nobilis*. Other than the type, only two additional specimens had been determined as this taxon, one of which (*V.Levitzke* 561) could not be located at the State Herbarium of Adelaide (AD).

***Ptilotus nobilis* subsp. *angustifolius* (Benl) Lally & W.R.Barker, comb. et stat. nov.**

Ptilotus nobilis var. *angustifolius* Benl, Mitt. Staatssamml. Bot. München 3: 43 (1959). — **Type:** South Australia: Flinders Range, Oct. 1901, *M.Koch* s.n. [575] (holo: M 0152673, n.v., digital image at CANB; iso: NSW 29534, NSW 790629, both n.v., digital images at CANB).

Distribution & notes. *Ptilotus nobilis* subsp. *angustifolius* is distributed in southern South Australia from near Quorn, north-east of Port Augusta, south to Victor Harbor (Fig. 1), but it is apparently uncommon and few recent collections exist. The type of *Ptilotus nobilis* var. *angustifolius* (Fig. 2) is thought to occur around Port Pirie, the South Australian collecting locality recorded for Max Koch in 1901 (Audas 1929). The subspecies grows on rocky slopes or hills, occurring in *Eucalyptus microcarpa* association.

Ptilotus nobilis subsp. *angustifolius* differs from subsp. *nobilis* by its narrow basal leaves with long attenuate bases, the leaf lamina usually less coriaceous than in subsp. *nobilis*, and its usually shorter and less robust habit. It is vegetatively similar to subsp. *semilanatus*, but differs in the much longer perianths and styles. Benl (1959) described *Ptilotus nobilis* var. *angustifolius* at varietal rank, but the distinction between this taxon and other infraspecific taxa within *P. nobilis* indicates subspecific rank is appropriate. This is also congruent with the approach adopted by Bean (2008) for eastern Australian *Ptilotus*.

Representative specimens examined

SOUTH AUSTRALIA. Back road SE from Quorn, 15 Oct. 1992, *K.M.Alcock* 214 (AD); Wirrabara, ca 30 km NE of Port Pirie, Oct. 1932, *J.E.Brown* s.n. (AD96216068); Mt Brown, ca 25 km E of Port Augusta, 14 Oct. 1962, *H.M.Cooper* s.n. (AD96243015, AD97406207); Mt Brown Forest Reserve, Hd of Woolundunga Sect. 163, 13 Dec. 1984, *S.Dorsch* 029 (AD); Hallett Cove Conservation Park, 21 Oct. 1983, *D.J.E.Whibley* 8522 (AD, CANB); Baroota, s.dat., *S.A.White* s.n. (AD97919291); Yorke Peninsula, s.dat., leg.ign. s.n. (AD98115443).

***Ptilotus nobilis* subsp. *semilanatus* (Lindl.) A.R.Bean**

Telopea 12: 242 (2008). — *Trichinium semilanatum* Lindl. in T.Mitch., J. Exped. Trop. Australia 45 (1848). — *Ptilotus exaltatus* Nees var. *semilanatus* (Lindl.) Maiden & Betche, Census N.S.W. Pl. 72 (1916). — *P. semilanatus* (Lindl.) J.M.Black, Fl. S. Austral. ed. 2, 2: 327 (1948). — **Type:** New South Wales: Duck Creek, subtropical New Holland, 27 January 1846, *T.L. Mitchell* 74 (holo: CGE, n.v.; iso: MEL, n.v.).

Illustrations. G.M.Cunningham et al., Pl. Western N.S.W. 286 (1981), as *P. exaltatus* var. *semilanatus*; N.G.Walsh in N.G.Walsh & T.J.Entwistle (eds), Fl. Victoria 3: 211, fig. 37q–r (1996).

Distribution & notes. *Ptilotus nobilis* subsp. *semilanatus* occurs from eastern Queensland through northern New South Wales to north and north-western Victoria, and just across the border into south-eastern South Australia near Bordertown (Fig. 1).

This taxon shares the narrow basal leaves with long attenuate bases and the usually hemispherical or ovoid inflorescences, with subsp. *angustifolius*, but differs from this subsp. in the shorter perianths and styles.

3. *Ptilotus spathulatus*

Some morphological variation in floral characters is evident in this species, and this presumably led Benl (1965) to erect *P. spathulatus* f. *angustatus*, distinguished by long, narrow spikes, short perianths, bract and bracteoles, and tepal apices projecting beyond the short tepal hairs. However, morphological variation in this species, including the characters used by Benl to circumscribe f. *angustatus*, is continuous, and does not allow for the recognition of separate entities. There is also no apparent geographic or ecological correlation with the observed variation in *P. spathulatus* sens. lat. Accordingly, *P. spathulatus* f. *angustatus* is here formally reduced to a synonym of *P. spathulatus*.

***Ptilotus spathulatus* (R.Br.) Poir.**

in J.B.A.P. de Lamarck, Encycl. Suppl. 4: 620 (1816). — *Trichinium spathulatum* R.Br., Prodr. 415 (1810). — *Ptilotus spathulatus* (R.Br.) Poir. f. *spathulatus*, Mitt. Bot. Staatssamml. München 5: 568 (1965). — **Type:** Tasmania: Derwent River, above the fall, 29 Mar. 1804, *R.Brown* [Bennett No. 3051] (holo: BM 000900536, n.v., digital image at CANB; iso: K, n.v.).

Trichinium mucronatum Nees in J.G.C.Lehmann, Pl. Preiss. 1: 628 (1845). — **Types:** in regionibus interioribus Australiae meridionali-occidentalis, Martio a. 1841, *L.Preiss* 1366 (syn: ?LD, n.v.; BM 00895601, n.v., digital

image at CANB); in limoso-calculosis ad latus orientale montis Brown prope urbiculum York, Septembri a. 1839, *L.Preiss 1363* (cum *Trichinio humili*) (syn: ?LD, n.v.); Swan River, 1843, *L.Preiss 1373* (syn: G-DC G00200111, n.v., digital image at CANB, MEL, n.v.).

Ptilotus spathulatus f. *angustatus* Benl, Mitt. Bot. Staatssamml. München 5: 568 (1965), **syn. nov.** — **Type:** South Australia: Yandinga Falls, c. 32 km N of Minnipa, 16 Oct. 1958, *P.G.Wilson 508* (holo: AD 95931068; iso: B, M, n.v.)

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A new subspecies in *Choretrum spicatum* F.Muell. (Santalaceae) from South Australia

B.J. Lepschi

Australian National Herbarium, Centre for Plant Biodiversity Research,
G.P.O. Box 1600, Canberra, Australian Capital Territory 2601
E-mail: Brendan.Lepschi@csiro.au

Abstract

Choretrum spicatum subsp. *continentale* Lepschi is described as new. Notes on distinguishing this taxon from *C. spicatum* F.Muell. subsp. *spicatum* are provided, and both taxa are illustrated.

Key words: Santalaceae, *Choretrum*, nomenclature, taxonomy, South Australia.

The genus *Choretrum* R.Br. comprises approximately eight species distributed throughout southern temperate Australia, and is currently under revision by the author. Preparation of a treatment of the Santalaceae for the forthcoming revised *Flora of South Australia* has necessitated the description of a new subspecies of *C. spicatum* F.Muell. in advance of the full taxonomic revision of the genus.

Choretrum spicatum subsp. *continentale* Lepschi, subsp. nov.

A Choretrum spicatum subsp. spicato foliis vegetativis appressis ad ascendentibus differt.

Holotypus: South Australia: Desert Camp Conservation Park, c. 1 km SW of Keith–Naracoorte Road on road to Kingston SE, 31 Dec. 2002, B.J.Lepschi & A.J.Whalen 4902 (CANB 733709.1). **Isotypi:** AD, BRI, CANB 733709.2, CHR, E, G, HO, K, L, MEL, MO, NSW, P, US.

Erect *shrub* 0.8–1.5 m high, green, glabrous. *Branchlets* rigid to more or less flexible, terete, longitudinally ridged, the ridges minutely tuberculate to smooth; fertile branchlets 1.3–2 mm diameter. *Leaves* persistent (retained on the branchlets and gradually weathering away), scale-like, sessile, appressed to ascending (spreading-ascending to spreading when subtending inflorescences), distal portion rarely slightly incurved or, on older leaves, spreading to recurved, triangular to very-narrowly triangular, 1.3–2 mm long, 0.5–0.6 mm wide; base truncate, apex narrowly acute to acute, margin entire to fimbriate. *Inflorescences* of single pedunculate flowers inserted laterally on the branchlets; flower subtended by 10–14 bracts, 4 of which are involucre. *Peduncle* obscured by bracts, 0.3–1 mm long, straight. *Bracts* persistent to fruiting stage, scale-like, sessile, cupped (lowermost bracts occasionally slightly keeled), scarious; ovate to broadly ovate or rounded-triangular, 0.6–1 mm long, 0.4–1.2 mm wide, lunate in cross section; base truncate, apex

acute to rounded or acuminate (occasionally shortly so), margin fimbriate. *Flowers* obscurely pedicellate, floral tube and pedicel 1–1.5 mm long; receptacle margin lobed, the lobes depressed triangular to depressed ovate, 0.1 mm long. *Tepals* more or less ovoid, 1–1.3 mm long; apex incurved, prominently hooded and thickened adaxially, with a small tuft of minute hairs on the adaxial surface above the point of filament insertion, more or less smooth to indistinctly longitudinally striate when dry, white, occasionally flushed reddish-maroon (in life and when dry). *Anthers* broadly obovate, 0.3–0.4 mm long; filaments 0.15–0.2 mm long. *Disc* shallowly to moderately lobed, moderately concave, 1–1.5 mm diameter. *Style* 0.15–0.2 mm long; stigma obscurely stellate. *Drupe* subglobose to globose or broadly ellipsoid, longitudinally ribbed (due to ornamentation on endocarp) when dry, 3–4 mm long; epicarp thin, green, flushed pinkish-red with age (including the persistent tepals) in life, drying brownish-green, sometimes flushed deep red-maroon. Endocarp globose or broadly ellipsoid, longitudinally ribbed, c. 3–4 mm long. **Fig. 1.**

Distribution. Occurs in south-eastern South Australia in an area bounded approximately by Keith, Coola Coola Swamp and Frances, extending eastwards into Victoria, where it appears to be confined mainly to the western part of the Little Desert National Park. A small number of early collections (the latest from 1952) exist from the eastern portion of the Little Desert and the Dimboola district, but this taxon does not appear to have been collected from these areas in recent times. Records from Wyperfeld National Park in Jeanes (1999) appear to be based on misidentified collections of *C. glomeratum* R.Br.

Habitat. Recorded growing in sand (including sand dunes), sand over clay and sandy loam, in heath or open eucalypt woodland (the latter often with a shrubby understorey), frequently in low-lying sites and swamps.

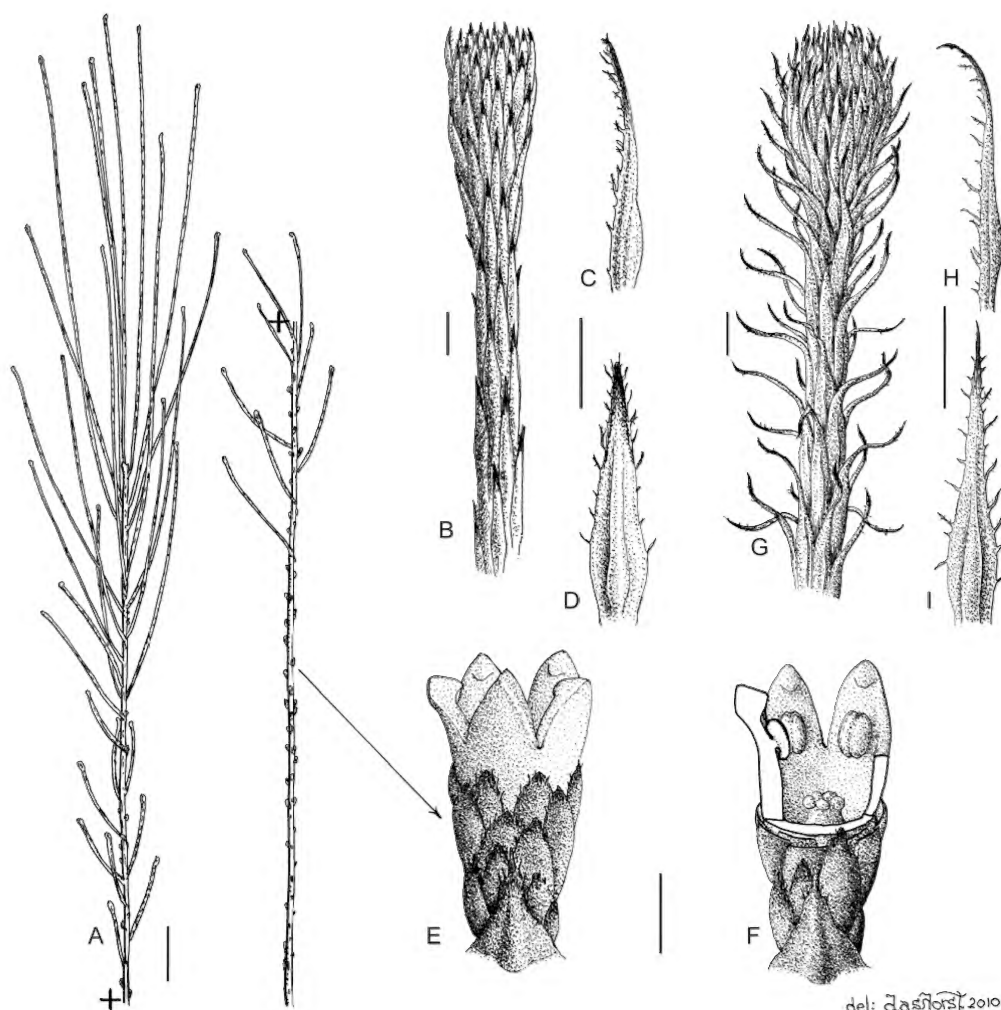


Fig. 1. *Choretum spicatum*. — A–F subsp. *continentale*: A flowering branch; B young growth; C leaf, side view; D leaf, abaxial view; E–F flower. G–I subsp. *spicatum*: G young growth; H leaf, side view; I leaf, abaxial view. Scale bars: A, B, G 1 mm; C–F, H–I 0.5 mm. — A–F Lepschi & Whalen 4902; G–I A.G. Spooner 3802 (AD).

Phenology. Flowers recorded in November and January, with plants collected between September and December generally in bud or very young flower. Fruits recorded in January, March and November.

Notes. Taxonomic differences between populations of *C. spicatum* on Kangaroo Island (the type locality) and those on the Australian mainland were noted by the late H.U. Stauffer (in Eichler 1965), who suggested that mainland plants might deserve specific status, an observation repeated by Hewson (1984) and Jessop (1986). Jeanes (1999) also commented on differences in leaf morphology between mainland and Kangaroo Island populations. Studies by the present author have

confirmed that mainland populations are taxonomically distinct. As the differences between mainland and Kangaroo Island populations are relatively minor, subspecific rank is considered appropriate.

Subspecies in *Choretum spicatum* may be distinguished by characters of the vegetative leaves (i.e. those not subtending inflorescences). These are best observed on young growth, as leaves gradually abrade and weather on older growth. In *C. spicatum* subsp. *spicatum* the vegetative leaves are spreading-ascending to spreading or recurved (Fig. 2), whereas in *C. spicatum* subsp. *continentale* vegetative leaves are appressed to ascending (Fig. 1). The orientation of the vegetative leaves is distinctive for each taxon, and can easily be

observed on young shoots without magnification. The distal portion of the leaf in *C. spicatum* subsp. *continentale* may rarely be slightly incurved or spreading to recurved on older leaves, and in very young growth of *C. spicatum* subsp. *spicatum* some appressed to ascending leaves may rarely occur (e.g. *Osborn s.n.*, AD 98008472), but both these states are infrequent, and overall leaf orientation remains diagnostic. Supplementary characters for separating subspecies in *C. spicatum* include narrowly acute to acute leaf apices in *C. spicatum* subsp. *continentale* (vs. very narrowly acute in subsp. *spicatum*) and entire to fimbriate leaf margins (vs. suberose to (usually) fimbriate in subsp. *spicatum*). Leaves in *C. spicatum* subsp. *spicatum* may also be contorted (in lateral view), a state not observed in subsp. *continentale*. Jeanes (1999) suggested leaf length and persistence as possible diagnostic characters for separating mainland and Kangaroo Island populations of *C. spicatum*, but these characters unfortunately have no discriminatory value in separating infraspecific taxa in this species.

From limited field observations in South Australia and Victoria by the author during December 2002, *C. spicatum* subsp. *continentale* apparently occurs in relatively low densities throughout much of its range, with individual plants often growing hundreds of metres from one another. This is supported by anecdotal observations in field notes on specimen labels, especially from Victoria, e.g. "One plant seen" (*Clarke 2235*), "One plant" (*Cornwall LD 13/89*), "Only saw two plants in more than 150 miles" (*Irvine s.n.*), "Extremely rare shrub, only two plants seen" (*Willis s.n.*, MEL 2063113). Jessop (1986) records *Choretrum spicatum* p.p. (= *C. spicatum* subsp. *continentale*) as "rare in the SE [of South Australia]", and the species is listed as Rare in Barker et al. (2005). Collectors field notes on herbarium specimens suggest that *C. spicatum* subsp. *spicatum* is also not an abundant taxon within its range.

Etymology. Named from the Latin *continentalis* (mainland, continent), in reference to this subspecies being restricted to mainland Australia.

Selected specimens examined

SOUTH AUSTRALIA. Sandy Ranges near Tilly's Swamp, *s.dat.*, *leg. ign. s.n.* (MEL 2267); 14.5 km S of Western Flat, 3 Mar. 1994, *T.Croft 406* (AD); c. 20 km N of Frances, 14 Jan. 1982, *R.Davies s.n.* (AD); Bordertown road, c. 6 miles [c. 10 km] S of Bordertown, 28 Oct. 1961, *D.Hunt 315* (AD); Desert Camp Conservation Park, 1 Dec. 1996, *D.Murfet 2588 & R.L.Taplin* (AD); 42 km S of Keith, at junction of Keith–Naracoorte and Kingscote–Bordertown roads, 10 Nov. 1974, *J.G.West 426* (CANB).

VICTORIA. Wimmera, *s.dat.*, *leg. ign. s.n.* (MEL 2270); Little Desert National Park, West Block, East–West track, adjacent to South Australian border, 8 Jan 1989, *G.Cornwall LD 13/89* (MEL); Sand hills near Reedy Creek, *s.dat.*, *C.H. Irvine s.n.* (MEL 2268); 1.3 km N of East–West Track on Mt Moffat Track, Little Desert National Park, 31 Dec. 2002, *B.J.Lepschi & A.J.Whalen 4913* (AD, BRI, MEL, NSW, W); Banks of the Wimmera River, Dimboola, 26 Nov. 1896, *F.M. Reader s.n.* (MEL).

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Notes on *Hibbertia* (Dilleniaceae). 6. Three new species and a new combination in the *H. stricta* complex from South Australia and Victoria

H.R. Toelken

State Herbarium of South Australia, P.O. Box 2732, Kent Town, South Australia 5071

E-mail: hellmut.toelken@sa.gov.au

Abstract

Two new species, *Hibbertia devitata* Toelken and *H. setifera* Toelken, are segregated from the *H. stricta* (R.Br. ex DC.) F.Muell. complex. *H. glebosa* Toelken is newly described from the *H. australis* N.A.Wakef. complex and the new combination *H. glebosa* subsp. *oblonga* (J.M.Black) Toelken is made. All three species have strongly revolute leaf margins. The many local variants of *H. devitata*, which is a common and widespread species, mainly in South Australia, are described in detail, and some of the convoluted nomenclature of the *H. stricta* complex is discussed.

A key is provided to the South Australian species and subspecies that would have been included in Bentham's concept of *H. stricta*.

Keywords: Dilleniaceae, *Hibbertia*, nomenclature, taxonomy, southern Australia, South Australia, Victoria.

Introduction

Bentham (1863) commented that *H. stricta* (R.Br. ex DC.) F.Muell. “is a very variable species”, and he included at least six previously recognised species as well as specimens of many taxa undescribed at the time, in this large complex. The need to recognise a wider range of taxa has become obvious from a study of the vast array of specimens collected since Bentham's work. Distinguished taxa, usually species, are often geographically isolated but they are usually not easily recognised due to their intricately interwoven characters. This is presumably why Bentham placed them in a “superspecies”. He had too few specimens to enable the delimitation of the taxa recognised here.

Wakefield (1955) started to unravel this unwieldy complex when he segregated *H. australis* N.A.Wakef., *H. calycina* (DC.) N.A.Wakef. (first described as a species of *Pleurandra* Labill.) and *H. cistiflora* N.A.Wakef. Here three more peripheral species pertaining to the *Flora of South Australia* are described as a complete revision of the *H. stricta* complex will need much more research (Toelken, in preparation).

This paper is the author's sixth contribution on the taxonomy of *Hibbertia*. Previous papers were published in *Journal of the Adelaide Botanic Gardens*, volumes 16 (1995), 18(2) (1998), 19 (2000), 20 (2002) and 23 (2010).

The following key to all the South Australian taxa that would have been incorporated in Bentham's concept of *H. stricta* also includes *H. riparia* (R.Br. ex DC.) Hoogland.

Key to species and subspecies

of the *H. australis*-, *H. riparia*- and *H. stricta* complexes in South Australia

1. Flowers sessile — if rarely with peduncle up to 14 mm then leaves and calyx glabrescent (small and scarcely visible to the naked eye) or glabrous
2. Axils of leaves with erect tuft of hairs 0.5–2 mm long and usually continued on both sides of the leaf base along the junction with branches; leaves and branches with straight simple and fascicled hairs *H. riparia*
- 2: Axils of leaves without or with tufts of erect hairs < 0.4 mm long; leaves and branches with fascicled hairs, rarely also with simple hooked ones
3. Large stellate hairs on the outer calyx lobes with unequally long bristles 3 to 8 times longer than base tomentum; small hairs on branches and calyx dense, erect-spreading with subequal arms *H. setifera*
- 3: Large stellate hairs on the outer calyx lobes with subequal branches up to 2 times longer than base tomentum; small hairs on branches, leaves and calyx sparse, spreading or if dense then with unequally long arms *H. devitata*
- 1: Flower stalk > 5 mm long
4. External surface of outer calyx lobes smooth (fig. 1D) and with dense cover of small fascicled hairs overtopped by scattered spreading larger ones often with basal tubercle but without lumpy projection of leaf tissue
5. Plants decumbent or scrambling; flowers terminal, becoming leaf-opposed along branches; hairs on upper leaf surface ± appressed, scattered to sometimes glabrescent *H. tenuis* Toelken & R.J.Bates
- 5: Plants erect to spreading, rarely with some decumbent branches; flowers terminal on terminal and axillary short shoots, rarely obviously leaf-opposed; hairs on upper leaf surface erect, usually dense but soon glabrescent *H. australis*

- 4: External surface of outer calyx lobes lumpy due to scattered, apparently stalked (fig.1C), large spreading fascicled hairs overtopping few scattered smaller ones *H. glebosa*
6. Bracts more than half the length of the outer calyx lobes, 5.5–7 mm long; leaves 0.6–0.8 mm wide *H. glebosa* subsp. *glebosa*
- 6: Bracts less than half the length of the outer calyx lobes, 4.3–5.2 mm long; leaves 1–2 mm wide *H. glebosa* subsp. *oblonga*

Terminology

The three new species, as well as morphologically similar species referred to in the discussion, all have strongly revolute leaf margins, so that “leaves above” here refers to that part of the upper (adaxial) leaf surface that is visible from above. The lower (abaxial) leaf surface is not visible except for the central vein, while the “undersurface” (Toelken 1998, 2000) is hidden between the revolute margins and the bulging central vein. “Leaves below” refers to the strongly revolute parts of the adaxial leaf surface and the central vein of the abaxial leaf surface.

Hair terminology follows concepts used in previous papers of this series and especially Toelken (2010).

A hypophyll, which is “a reduced or modified leaf towards the upper end of a shoot” (Jackson 1965) refers here mainly to the distinctly enlarged leaves below flower clusters in the *H. sericea* group (Toelken 2000).

In species of the *H. australis* group measurements of the stalk below the flowers combine both the variously elongated ultimate and penultimate internode referred to in other species of *Hibbertia* as pedicel and peduncle respectively. It is called a flower stalk to draw attention to the difference.

The distribution range of the species is cited in currently used regions as documented in the Flora of South Australia (Jessop & Toelken 1986) and Flora of Victoria (Walsh & Entwistle 1993–1999).

H. devitata and *H. setifera* of the *H. stricta* complex

H. setifera and especially *H. devitata* are two newly recognised species close to *H. stricta* s. str. from eastern Australia. *H. devitata* and *H. setifera* are considered to belong to the *H. stricta* complex on the basis of the presence of leaf-like bracts with revolute margins and the absence of well developed intrapetiolar tufts of hairs. *H. devitata* is only now described although specimens of it were already examined and cited by Bentham.

While de Candolle (1817) published both *Pleurandra riparia* R.Br. ex DC. and *P. stricta* R.Br. ex DC., J.D.Hooker (1855) considered the two species to be conspecific and included *P. stricta* in the synonymy of *P. riparia*. Bentham (1863) however, reversed the situation by including *P. riparia* in *Hibbertia stricta* the older name in *Hibbertia* following the Kew Rule rather than the present Principle of Priority of the International Code of Botanical Nomenclature (McNeil et al. 2006).

Hoogland (1974) made the new combination *Hibbertia riparia* (R.Br. ex DC.) Hoogland, pointing out that Hooker’s original choice must, according to Article 11 of the *International Code of Botanical Nomenclature* (Stafleu et al. 1972; this corresponds to Art 11.5 of the current *Code*: McNeil et al. 2006) be adhered to. Hoogland also considered “the type of *Pleurandra stricta* in the de Candolle herbarium in Geneva agrees in all respects with the species currently referred to as *Hibbertia australis* N.A.Wakef.”. An examination of this specimen in Geneva by the author could clearly identify it and distinguish it from all other presently known species. Since it has sessile flowers and leaves and branches with small scattered fascicled hairs, it is not *H. australis*. Until a revision of the whole complex (Toelken, in preparation) has been completed it is not possible to finally delineate *H. riparia* and *H. stricta*, the oldest species in the group. Toelken (1996), realizing this, provisionally reverted to Bentham’s broad approach, but under the name of *H. riparia*, as Hoogland had correctly pointed out. The few taxa published here will not be affected by the final typification and delineation of the eastern Australian species *H. australis*, *H. riparia* and *H. stricta*.

Both J.D.Hooker (1855) and Bentham (1863) used in their respective taxonomies a var. *glabriuscula* (Art. 35.4 of the ICBN denotes them as varieties, as the authors did not indicate rank; McNeill et al. 2006). W.J.Hooker (1834) described *P. riparia* a *glabriuscula* based on five specimens collected by Gunn and Lawrence from Tasmania and this was adopted by J.D.Hooker (1855). However Chapman (1991: 1590) indicated that the Hookers’ var. *glabriuscula* seemed to represent the typical variety. If this is so then this would make this name illegitimate in this combination, but this would need to be resolved in a revision of *H. riparia* s. str. (Toelken, in preparation).

It is not clear from Bentham’s citations whether his “*H. stricta* a *glabriuscula*” was based on Hooker’s variety of *H. riparia*. While the Hookers’ two herbaria were the basis for much of Bentham’s work on the *Flora Australiensis*, he did not specifically mention the Gunn and Lawrence collections and made no reference to any of the four varieties described by the Hookers. It seems therefore that Bentham’s var. *glabriuscula* was intended to be a new taxon. The variety needs to be lectotypified on an eastern Australian specimen, preferably *Sieber 150* or *Sieber 151*, as Bentham (1863) cited them specifically and considered them part of the “commonest form”.

J.M.Black (1926, 1952) applied the name *H. stricta* var. *glabriuscula* to South Australian specimens. Wakefield (1955) stated: “In north-western Victoria (Dimboola, Lake Hindmarsh etc.) and in South Australia there are tiny desert forms which are smaller in all parts and with very little vestiture.” Varieties were not recognised by Hoogland (1974) when he returned the name to *H. riparia* and not by Jessop (1986) in his treatment in the *Flora of South Australia*. In both cases

H. stricta var. *glabriuscula* was treated as a synonym of *H. riparia*. Recognition of the South Australian taxon as a species was first made in the allocation by this author (Toelken 2005) of the phrase name *Hibbertia* sp. *Glabriuscula* (D.J. Whibley 9012). Unfortunately it was not possible to name the present species as *H. glabriuscula* in order to maintain a recognizable name for a very common plant in South Australia. This was thwarted by the naming of *H. glabriuscula* J.R. Wheeler (1994), a species from the northern wheatbelt areas of Western Australia.

Hibbertia devitata is delineated and finally named here after being recognised as distinct for more than 140 years. In contrast, the newly described *H. setifera* has a relatively stable nomenclatural history having been referred to either *H. stricta* or *H. riparia* in the past.

***Hibbertia devitata* Toelken, sp. nov.**

A H. stricta foliis brevioribus (rare longioribus quam 10 mm) veni centrale protruberante ovariisque tomentosis; a H. riparia sine pilis simplicibus parciue in axillis foliorum lobisque calicorum cum cristis centralibus differt.

Type: South Australia, Carcuma Conservation Park, E.N.S. Jackson 5669, 4.ix.1985 (holo.: AD; iso.: BRI, CANB, G, K, MEL, MO, NSW, NY, PERTH).

Hibbertia sp. *Glabriuscula* (D.J. Whibley 9012) Toelken in W.R. Barker et al., J. Adelaide Bot. Gard. Suppl. 1: 50 (2005).

Hibbertia stricta auctt. non (R.Br. ex DC.) F. Muell.: Tate, Fl. Extratrop. S. Austral.: 4, 205 (1890), p.p.; J.H. Willis, Handb. Pl. Victoria 2: 389 (1972), p.p.

Hibbertia stricta (R.Br. ex DC.) F. Muell. var. *glabriuscula* auctt. non Benth.: Benth., Fl. Austral. 1: 27 (1863), p.p. as for "Lake Hindmarsh, in Victoria"; J.M. Black, Fl. S. Austral. 3: 387 (1926); ed. 2, 3: 576 (1952) – non *H. glabriuscula* J.R. Wheeler, Nuytsia 9(3): 430 (1994).

Hibbertia riparia auctt. non (R.Br. ex DC.) Hoogland: Jessop in Jessop & Toelken, Fl. S. Austral. 1: 357 (1986), p.p.; Toelken in N.G. Walsh & Entwistle, Fl. Victoria 3: 312 (1996), p.p.

Shrublets up to 0.8 m tall, sparse to often much-branched, usually stiffly erect; branches with pronounced leaf bases continued in decurrent flanges, puberulous to glabrescent, rarely pubescent or tomentose. *Vestiture* very variable, persistent or wearing off to glabrous but usually remaining finely tuberculate, mainly with fascicled hairs on most parts of the plant and sometimes with interspersed hooked simple hairs particularly on the calyx; *on branches* sparse to dense, with short subequal fascicled hairs (3–5 (–7) spreading arms, often unequal, each often less than 0.1 mm) without basal tubercle; *on leaves above* sparse to glabrous, rarely pubescent, with short fascicled hairs (1–3 (–5) usually unequal arms), often reduced to a basal tubercle, but the hairs denser and with slightly longer arms on the flanks of the revolute margins, which are rarely overtopped by few hooked simple hairs; *on leaves below* sparse to dense with short fascicled hairs (3–5 (–8) usually subequal, rarely unequal arms), often with pronounced basal tubercle, but sometimes overtopped by scattered

larger fascicled hairs (12–15 subequal arms); *on bract* similar to but smaller than leaves; *on outer calyx lobes* outside sparse to dense with small (1–3 (–5) often unequal arms) grading into larger, often tubercled-based fascicled hairs (7–14 (–25) subequal arms), in local populations rarely overtopped with erect hooked simple hairs, inside usually dense with larger and smaller fine antrorse forked fascicled hairs (1, 2 or 3 arms) without tubercles on the upper third; *on inner calyx lobes* outside moderately dense to dense, rarely glabrous, with a cover of fine small fascicled hairs (1–3 (–6) spreading subequal arms) becoming gradually smaller towards the membranous margins, overtopped by few larger fascicled hairs (5–8 (–12) usually subequal arms) without tubercles and/or few hooked simple hairs mainly along the central ridge, inside glabrous. *Leaves* without tufts of hairs in the axils; *petiole* 0–0.7 mm long; *lamina* linear, rarely linear-lanceolate, (2.6–) 3.5–7 (–21.5) × (0.9–) 1–1.3 (–1.5) mm, bluntly acute to usually obtuse, abruptly constricted into the petiole, above slightly concave to almost flat, puberulous to often glabrescent, rarely pubescent, below with prominent central vein usually bulging over narrower revolute margins and puberulous to glabrescent. *Flowers* single, sessile or rarely with peduncle up to 14 mm (Port Lincoln), on terminal and lateral branches, often subtended by few bract-like leaves on fascicled axillary branches; *bracts* linear, leaf-like, 2.2–3.4 × 0.6–0.8 mm, usually less than half as long as outer calyx, with prominent central vein, puberulous. *Calyx* lobes subequally long; *outer calyx lobes* lanceolate, (5.4–) 6.2–6.7 (–7.3) × (1.8–) 2–2.5 (–2.8) mm, often slightly longer than the inner lobes, pointed and with distinct ridge often along the whole length, pubescent often overtopped by more or less hooked simple hairs; *inner calyx lobes* ovate to oblong-ovate, (5.2–) 6–6.5 (–7) × (3–) 3.2–3.5 (–3.9) mm, cuspidate to rounded, very slightly ridged mainly at the base, finely pubescent often overtopped by larger fascicled and/or ± hooked simple hairs. *Petals* (4–) 6–9 (–11.8) mm long, emarginate. *Stamens* (5–) 6–8 (–12) in a dense dorsal cluster with the central 1–2 (–3) stamens distinctly longer; *filaments* incurved and resting on ovary, almost free to connate for up to half their length; *anthers* 1.4–2.2 mm long, abruptly constricted apically and basally. *Pistils* 2; *ovaries* obovoid, each with 4–6 lateral ovules, pubescent, with styles attached to apex, erect and on either side of the anther bundle, with stigmas born well above anthers. *Seed* obovoid, 1.8–2 × 1.6–1.7 mm, dark brown to black; *aril* fleshy at the base and expanding into a fleshy rim on the lower third of the seed. *Flowering*: (June–) August–November. **Fig. 1A.**

Distribution and ecology. Widespread in a range of habitats varying from gravelly slopes to deep sandy soils and usually associated with dry scrub or open woodland, especially mallee, in Victoria (LMAL, MMAL, WAN, WIM) and South Australia (EP, NL, MU, YP, SL, KI, SE).

Conservation status. Since the species is widespread and recorded from several conservation parks it would

appear not to be a candidate for conservation status in South Australia.

Diagnostic features. *Hibbertia devitata* differs from typical forms of *H. stricta* in having shorter leaves (rarely more than 10 mm long) with a markedly bulging central vein and densely hairy ovaries.

It is also very similar to *H. riparia* with which it is often sympatric in the Southern Lofty, Kangaroo Island and South Eastern regions of South Australia and adjoining Victoria. *Hibbertia devitata* is, however, distinguished by: the absence of distinct tufts of long hair in the axils (intrapetiole) of the leaves, present in *H. riparia*; occasional presence of hooked simple hairs on the leaves and especially the outer calyx, whereas straight simple hairs are common in *H. riparia*; a broad central leaf vein usually bulging well above the revolute margins as opposed to more or less touching the revolute margins; apically acute to pointed outer calyx lobes with a distinct central ridge on at least the upper half compared to bluntly acute and without ridge on the upper half; 1 (–3) longer central anther(s), inclining over and leaning on the ovaries between the styles as opposed to the similar number of erect stamens not touching the ovaries in *H. riparia*.

Some forms of *H. devitata* can be confused with *H. australis* and *H. glebosa*. *H. devitata* differs from the *H. australis* complex by: sessile flowers or if with stalk more than 5 mm long then plants glabrous or glabrescent, as opposed to with flower stalk more than 5 mm long and plants are hirsute to sparsely hirsute; all of its fascicled hairs particularly on the outer calyx are usually of more or less similar size, or the larger and smaller ones grade into one another, and are often mixed with simple hairs (distinctly larger hooked ones over smaller fascicled hairs particularly on the calyx) as compared to distinctly larger over smaller fascicled ones; one to several bracts which have a similar shape and revolute margins as the leaves, while only one bract with revolute margins is found in *H. australis*.

Variation. *Hibbertia devitata* is a very variable species. A number of forms are recognised by the prevalence of a single character in peripheral populations but these usually gradually grade into the main population. At this stage there is no evidence for hybridisation or introgression between such populations as has been observed in the *H. virgata* complex (Toelken, in preparation). The following discussion attempts to demonstrate that local characteristics and their variation in some populations could not be correlated with others and/or geography to allow taxonomic delineation.

1. Hooked simple hairs with or without shorter fascicled hairs are more or less common on calyx lobes particularly in populations from near Port Lincoln, the Adelaide Hills, South Eastern Region and western Grampians. In extreme cases they are associated with leaves recurved from the base. These leaves are also more or less grooved along the upper

surface and the slender flower buds have pointed outer calyx lobes. The fascicled hairs on the flanks of the leaves are sometimes reduced to what appear to be simple hairs, but occasionally a hair will show a rudimentary second arm at the base. Hooked simple hairs (apparently not fascicled) are sometimes even found on the flanks of the revolute margins of the leaves (*P. Batchelor 41*).

2. Another form somewhat morphologically similar to the above occurs in mallee or scrub on sandy soil with surface limestone on the south-eastern Eyre Peninsula (*R.J. Bates 6909*), southern Yorke Peninsula (*R.D. Hoogland 11848*) and north-western Kangaroo Island (*H.R. Toelken 9216*). The flowers are more or less stalked (up to 14 mm: *K.C. Holliday 83042A*), the calyx is glabrous to minutely hairy and plants have wiry branches, purple when young (*R.D. Hoogland 11848*), are often little-branched and have more or less spreading-recurved leaves and their apex is often acute (*R.J. Bates 6909* also with exceptionally long leaves up to 21.5 mm). However, in none of the three areas can one distinguish a single population recognisable by consistently linking any two of these characteristics, while some of these characters, such as glabrous leaves and calyx are also observed in other populations of the typical species (e.g. *P.J. Lang & P.D. Canty BS128-1902*, Mt Wedge). Some of the more woody plants might be confused with glabrescent forms of *H. riparia*, because the central vein of leaves is often not so prominently bulging above the revolute margins, as is typical for *H. devitata*. However, all the specimens are readily identifiable as *H. devitata* due to the prominent ridge on the outer calyx lobes, and absence of intrapetiole tufts of hairs.
3. An extremely robust form particularly from the higher parts of the western Gawler Ranges (e.g. Scrubby Peak) has up to 12 stamens, and the larger fascicled hairs on the outer calyx lobes have 12–25 arms (*R.J. Bates 3355*; *E.H. Ising AD966040385*). Specimens from lower altitudes (e.g. *C.R. Alcock 4069*) exhibit characters that grade into those of the populations commonly found on the northern Eyre Peninsula.
4. The number of stamens varies from the usual six to eight to as high as twelve in some populations on northern Eyre Peninsula. The 1–2 (–3) central stamens have distinctly longer anthers which lean between the styles over the ovaries. In different populations the filaments vary from almost free to connate for up to half their length.
5. The outer calyx lobes vary in some populations from ovate (usually 3–5.5 mm long) to narrow-lanceolate (usually 5–8 mm long). Both types have a prominent central ridge more pronounced towards the apex. There are, however, herbarium specimens where the characteristic ridge is hardly visible, particularly in

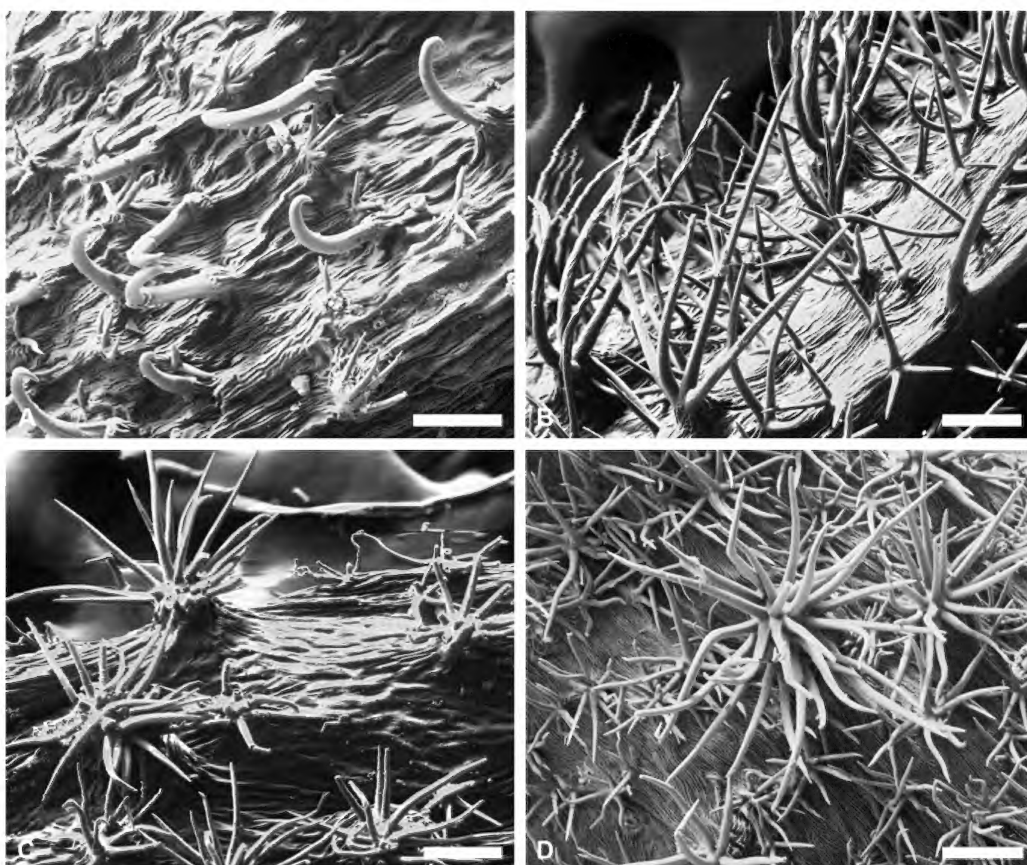


Fig. 1. Hairs on outer surface of outer calyx lobes. **A** *H. devitata*, small and larger fascicled hairs overtopped by hooked simple hairs; **B** *H. setifera*, smaller fascicled hairs overtopped by prominent larger coarse ones; **C** *H. glebosa* subsp. *glebosa*, very few small fascicled hairs overtopped by mainly scattered very large ones, which are often apparently stalked, because of a lumpy surface; **D** *H. australis*, dense small fascicled hairs overtopped by scattered distinctly larger ones on a more or less smooth surface. Scale bars: 100 µm. — **A** E.N.S.Jackson 1635; **B** H.R.Toelken 9241; **C** A.M.Ashby 749; **D** A.A.Munir 5455. — Whole calyx lobes mounted on specimen holders and scanned uncoated using a JEOL Neoscope JCM-5000 Table Top SEM (Nikon, Tokyo) under low vacuum; accelerating voltage 15 kV.

the South-Eastern Region (*D.Hunt* 2043), or on the southern Eyre Peninsula (*C.R.Alcock* AD98819052).

Etymology. The species name is derived from ‘devitata’, Latin, ‘shunned’, an allusion to this species being long known from South Australia, but defying being named for 140 years.

Selection of specimens examined (ca. 750 seen)

VICTORIA. **D.E.Albrecht** 1155, 3 km into Red Bluff, 3.xi.1984 (MEL); **A.C.Beaglehole** 38171, 18 miles ESE Nelson, 2.ii.1972 (MEL); **C.French** MEL 35906, NW Lake Albacutya, ix.1887 (MEL); **R.D.Hoogland** 11870, 9 miles S Kaniva, 18.xi.1970 (MEL; CANB, K, L – n.v.); **M.E.Phillips** NBG612627, Lowan Sanctuary, near Kiata, 9.ix.1961 (MEL).

SOUTH AUSTRALIA. **EP:** **C.R.Alcock** 4069, Yardea homestead, 3.x.1972 (AD, CANB); **C.R.Alcock** AD 98819052, Council boundary between Tumby Bay and Cleve, 16.ix.1965 (AD); **R.J.Bates** 3355, Scrubby Peak,

9.ix.1983 (AD); **R.J.Bates** 6909, 20 km SW Port Lincoln, 31.viii.1986 (AD); **J.S.Browne** MEL 35964, Port Lincoln, 1874 (MEL); **K.C.Holliday** 830424A, Warrilla Conservation Park, 17.vi.1983 (AD); **E.H.Ising** AD 966040385, N Minnipa, 13.ix.1938 (AD); **P.J.Lang & P.D.Canty** BS 128-1902, Mt Wedge, 17.ix.2003 (AD). **MU:** **K.Czornij** 369, Swan Reach, 17. ix.1971 (AD); **N.N.Donner** 286, Dingo Range, 31.viii.1961 (AD); **E.N.S.Jackson** 2360, Scorpion Spring National Park, 23.x.1973 (AD); **A.G.Spooner** 2581, 5 km S Monarto South, 9.x.1972 (AD). **YP:** **B.J.Blalock** 618, 6 km SSE Moonta, 30.ix.1967 (AD); **B.Copley** 4153, SE Minlaton, 6.x.1973 (AD); **K.Czornij** 833, 25 km SW Warrooka, 14.ix.1974 (AD); **R.D.Hoogland** 11848, 2 mls NW Stansbury, 12.xi.1970 (AD; CANB, HBG, K, L, UC, NSW, UC – n.v.); **W.L.Quin** 9, 12 km S Urania, 14.viii.1979 (AD). **SL:** **P.Batchelor** 41, Kuitpa Forest, 2.5 km along Mingka Track, 21.xii.1988 (AD); **D.N.Kraehenbuehl** 630, The Pinery, Grange, 15.ix.1962 (AD); **B.Paton** 111, 18 km W Victor Harbour, 22.vi.1974 (AD); **B.M.Routley & D.M.Armstrong** BS117-761, 2.4 km

WNW Williamstown, 7.i.2000 (AD); *D.J.E. Whibley* 1716, Spring Mount, 23.xi.1966 (AD). **KI:** *R.J. Bates* 61174, Cape Borda, ix.2003 (AD); *P.J. Lang & A. Maguire* NP KI 30525, 7 km S Nepean Bay South, 13.xi.1989 (AD); *J.G.O. Tepper* AD 97828177, Mt Pleasant to Birchmore Lagoon, 6.iii.1886 (AD); *H.R. Toelken* 9216, 1.4 km southwards along Church Road, 16.x.1997 (AD); *P.G. Wilson* 774, 11 km SW Kingscote, 6.xi.1958 (AD). **SE:** *J.W. Green*, 2 miles N Keith, 23.8.1958 (AD); *R.D. Hoogland* 11864, Mt Misery, 17.xi.1970 (AD); A, B, CANB, G, HBG, K, L, MEL, NSW, OKLA, PERTH, UC, TNS – n.v.); *D. Hunt* 2043, SE Lucindale, 6.vi.1964 (AD); *E.N.S. Jackson* 1635, ca 4 km SE Nine Mile Well, 4.xi.1969 (AD); *E.N.S. Jackson* 4616, Talapar Conservation Park, 5.x.1982 (AD); NBG, NEU, NSU, NSW – n.v.).

***Hibbertia setifera* Toelken, sp. nov.**

Hibbertiae australi similis sed floribus et fructis plus minusve sessilibus et non recurvatis pilisque setaceis in calicis 4–8plo longioribus quam illis Hibbertiae australis; a H. devitata pilis fasciculatis magioribus et densioribus, foliis plus minusve planis, stylis affixis in paginis lateralibus ovariorum differt.

Type: South Australia, Kangaroo Island, near Kelly Hill Caves, *H. Eichler* 15222 (holo.: AD; iso.: K, MEL, MO, NSW).

Hibbertia sp. *Glabriuscula* (*D.J. Whibley* 9012) Toelken in W.R. Barker et al., *J. Adelaide Bot. Gard. Suppl.* 1: 50 (2005), p.p.

Hibbertia stricta auctt. non (R.Br. ex DC.) F. Muell.: Benth., *Fl. Austral.* 1: 27 (1863), p.p., as for *F. Mueller* MEL 35738.

Hibbertia stricta (R.Br. ex DC.) F. Muell. var. *glabriuscula* auctt. non Benth.: J.M. Black, *Fl. S. Austral.* 3: 387 (1926), p.p.; ed. 2, 3: 576 (1952), p.p. – non *H. glabriuscula* J.R. Wheeler, *Nuytsia* 9(3): 430 (1994).

Hibbertia riparia auctt. non (R.Br. ex DC.) Hoogland: Jessop in Jessop & Toelken, *Fl. S. Austral.* 1: 357 (1986), p.p.; Toelken in N.G. Walsh & Entwisle, *Fl. Victoria* 3: 312 (1996), p.p.

Grey shrublets to 0.5 m tall, sparse to much-branched, erect to spreading, rarely decumbent; branches with prominent leaf bases continued in decurrent flanges, pubescent to tomentose. Vestiture persistent, with fascicled hairs often of similar size on the same organ; *on branches* ± dense with subequal short fascicled hairs (3–5 often subequal arms); *on leaves above* moderately dense with subequal erect-spreading fascicled hairs (3–5 often subequal arms) increasing in size towards the margins (apparently ciliate) with larger usually more robust hairs (7–12 often subequal arms) and usually obviously tubercled; *on leaves below* moderately dense with larger (9–15 subequal spreading to reflexed arms) over smaller fascicled hairs (4–7 reflexed arms); *on bracts* similar to leaves but hairs on marginal flanks more pronounced; *on outer calyx* outside very dense with a cover of smaller hairs (7–10 often unequal arms) overtopped by larger and very large fascicled hairs ((1–) 3–10 (–16) usually unequally long arms), inside moderately dense on upper half with spreading to antrorse arms; *on inner calyx* outside very dense with similar hairs (5–8 usually subequal reflexed arms) overtopped by larger and more robust hairs (5–10 often

unequal arms) mainly restricted to the central ridge, inside usually glabrous. *Leaves* with short, or rarely, without tuft of hairs in the axils; *petiole* 0–0.6 mm long, often indistinct; *lamina* linear-oblongate to -elliptic, (3.2–) 4–7 (–9.4) × 1.1–1.4 (–1.6) mm, cuneate base, rounded apex, above flat to slightly concave and sparsely hirsute, below with broad central vein slightly bulging above and abutting revolute margins, pubescent, rarely hirsute. *Flowers* single, sessile or subsessile up to 4 mm, on mainly long shoots, rarely on axillary short shoots; bracts linear-elliptic, leaf-like, 3.3–4.4 × 1–1.2 mm, about two-thirds as long as calyx, with broad central vein flattened, pubescent. *Calyx lobes* subequally long; *outer calyx lobes* lanceolate-oblong, 5.2–5.7 × (1.7–) 1.8–2.1 mm, acute with ridge often partially obscured by bristles, outside coarsely hirsute over tomentose, inside sparsely hirsute to pubescent; *inner calyx lobes* ovate-oblong, 5.2–5.6 × 2.9–3.2 mm, acute to cuspidate, tomentose and with dense bristles along the central ridge. *Petals* 4.3–6 mm long. *Stamens* (8) 9 in dorsal cluster; *anthers* subequal 1.4–1.6 mm long. *Pistils* 2; *ovaries* ovoid-compressed, with 4–6 ovules, with styles attached to dorsal upper side, erect on either side of the stamens and small stigma above anthers. *Fruit* erect. *Seeds* obovoid, 1.6–1.8 × 1.3–1.4 mm, black; *aril* cup-shaped with fleshy base. *Flowering*: mainly June–December.

Fig. 1B.

Distribution and ecology. Usually locally abundant on more or less sandy flats or on laterite in scrub or mallee-vegetation in Kangaroo Island, but also more rarely recorded from south-eastern South Australia and adjoining Victoria (LMAL, MMAL).

Conservation status. Locally common in Kangaroo Island (*B. Overton et al.* NP KI 20136) where it is conserved in several parks, but rarely recorded from the mainland of South Australia and Victoria with one specimen from each Scorpion Springs National Park and Wyperfeld National Park respectively.

Diagnostic features. Superficially *H. setifera* resembles species of the *H. australis* complex by its almost flat lower leaf surface with a very thick central vein scarcely higher than the touching revolute margins, by the erect to spreading hairs on vegetative organs and especially by the distinctly larger fascicled hairs overtopping the tomentum on the calyx. However, *H. setifera* differs from *H. australis* by its sessile/subsessile flowers, erect fruits and, most importantly, the leaf-shaped bracts, all of which place *H. setifera* closer to *H. devitata* in the *H. stricta* complex.

The habit of *H. setifera* resembles that of *H. devitata*. However *H. setifera* is not only distinguished by the size of the bristle-like arms of the robust fascicled hairs on the outer calyx, but also by a tendency for all hairs in all parts to have longer and more arms than any found in the many forms of *H. devitata*. The latter has, however, usually a distinctly convex lower surface of the leaves, while they are more or less flat in *H. setifera* as the

central vein is only slightly bulging and therefore more or less flush with the revolute margins.

Shrubs of *H. setifera* are of a similarly grey appearance to those of *H. crinita* Toelken because of the presence of the bristle-like arms of the fascicled hairs on the calyx and the longer hairs on the distal leaves below the flowers. *Hibbertia setifera* differs, however, by single terminal flowers not surrounded by broader specialised leaves (hypophylls) different from cauline leaves, the outer calyx lobes are without recurved margins, the flanks of the leaves lack simple hairs and the leaf undersurface is not visible between the revolute margins and the central vein. Similarly *H. setifera* is distinguished from *H. platyphylla* subsp. *platyphylla* by its leaves lacking any visible undersurface between the central vein and the revolute margins, by the central vein protruding above the leaf apex, and by the coarse hairs on the leaves and calyx commonly being fascicled.

Variation. Plants from Kangaroo Island usually have particularly long (up to 0.6 mm long) and coarse bristles on the calyx. These bristles are less prominent or in a few cases absent from a few flowers and present on others of the same plant from the South-Eastern Region of South Australia (*N.N.Donner 8471*) and Victoria (*D.Parkes MEL 556718*).

However, two specimens (*P.Coulls 19, M.C.O'Leary 2107*) from Kangaroo Island have shorter long hairs (0.2–0.3 mm and just longer than the tomentum) on the calyx, but are placed here, because of their sessile flowers and distinctly larger hairs on the flanks of the distal leaves in particular.

Similarly the lateral style attachment of some other specimens from the mainland is less obvious. But specimens of *H. setifera* stand out throughout the range of the species on account of their larger and denser fascicled hairs, which become even larger on distal leaves below flowers.

Note. A specimen, *F.Mueller MEL 35738*, from “Murray Desert” was seen and cited by Bentham (1863) under *H. stricta* in general, while specimens of *H. divitata* are mentioned under *H. stricta* var. *glabriuscula*.

Etymology. The specific epithet ‘seti-fera’, Latin, ‘bristle-bearing’, in allusion to the characteristic long bristles particularly on the outer calyx lobes.

Selection of specimens examined (36 seen)

VICTORIA. *R.Filson 7467*, 11 miles S Murrayville, 25.ix.1965 (MEL); *F.Mueller MEL 35738*, Murray Desert, s.d. (MEL); *D.Parkes MEL 556718*, Wyperfeld National Park, 19.x.1985 (MEL).

SOUTH AUSTRALIA. **KI:** *P.Coulls 19*, Vivonne Bay, 1.v.1983 (AD); *M.C.O'Leary 2107*, D'Estrees Bay, 15.ix.1990 (AD); *F.Mowling 77*, Hundred of Menzies, ix-x.1980 (AD); *B.M.Overton 1122*, 1.25 km W Point Ellen parking bay, 3.xii.1989 (AD) *A.Robinson et al. NPKI 10626*, 7.xi.1989 (AD); *J.G.O.Tepper 39*, Western Cove, 19.xi.1886 (AD); *H.R.Toelken 9241*, Highway near Vivonne Bay, 17.x.1997 (AD); *J.R.Wheeler 1371*, 6 km N Rocky River Homestead, 23.x.1968 (AD); **SE:** *P.Batchelor 156*, off Mt Rescue road,

19.xii.1995 (AD); *J.Carrick 3447*, Scorpion Spring National Park, 24.x.1973 (AD); *N.N.Donner 8471*, 3 km W Lucindale, 1.ix.1981 (AD); *M.C.R.Sherrard 1121*, 50 km S Pinnaroo, 29.viii.1961 (AD); *P.G.Wilson 2100*, 70 km N Bordertown, 29.viii.1961 (AD).

H. australis complex, including *H. glebosa*

Hibbertia australis was also included in the very broadly delineated *H. stricta* complex of Bentham (1863). In the absence of any revisions, subsequent treatments in local floras have followed Bentham's account, apart from that of Wakefield (1955), where he indicated that it too might be a species complex.

The *H. australis* complex is mainly distinguished from the *H. stricta* complex by its more or less stalked flowers and recurved fruits. This combination of characters is also found in the *H. cistoidea* complex (also included in *H. stricta* by Bentham, 1863) but that complex is confined to the northern parts of the eastern states and is further distinguished from the *H. australis* complex by its very broadly ovoid buds with ovate calyx lobes as well as a usually distinctly recessed central vein on the abaxial leaf surface (Toelken, in preparation).

Furthermore after the flowers are fertilised, veins at the base of the calyx lobes become more prominent and the whole base expands, in contrast to those of the *H. stricta* complex which have more or less pronounced distal ridges on the calyx. After the fruit and the calyx have been shed the flower stalks retain a very much bulging apex and this is another characteristic of the whole *H. australis* complex.

The distinctly larger fascicled hairs over the main cover of smaller ones, particularly on the calyx lobes, is another characteristic of the *H. australis* complex. A range of hairs of intermediate length is commonly associated with other groups of Bentham's *H. stricta*. Furthermore, the bracts of the *H. australis* complex differ from the leaves in shape and in the lack of a revolute margin, though rudiments of the latter can be recognised on some plants.

Hibbertia glebosa Toelken, sp. nov.

A. H. australe pilis fasciculatis grandibus semotis et ut videtur stipibus multicellularibus in lobis externis calicis folisque et lobis externis calicis glebosis ubi exsiccatis differt.

Type: South Australia, Mount Crawford, *R.J.Bates 35528*, 23.xii.1993 (holo.: AD; iso.: CANB, K, MEL, MO).

Hibbertia stricta var. *canescens* Benth., Fl. Austral. 1: 27 (1863), p.p.; J.M.Black, Fl. S. Austral. 3: 387 (1926), p.p.; ed. 2, 3: 576 (1952), p.p.

Hibbertia australis auct. non N.A.Wakef.: N.A.Wakef., Victorian Naturalist 72: 121 (1955), p.p.

Hibbertia stricta auctt. non (R.Br. ex DC.) F.Muell.: J.M.Black, Fl. S. Austral. 3: 387 (1926), p.p.; ed. 2, 3: 576 (1952), p.p.; Hoogland, Kew Bull. 29: 155 (1974), p.p.; Jessop in Jessop & Toelken, Fl. S. Austral. 1: 358 (1986), p.p.

Shrubs to 0.5 m tall, at first sparse but becoming much-branched, spreading to decumbent; branches

with prominent leaf bases not continued into decurrent flanges, sparsely hirsute, rarely pubescent. *Vestiture* often persisting only for short time, with larger fascicled hairs over smaller ones being often reduced to simple hairs; *on branches* sparse to locally dense, with a range of small to larger spreading fascicled hairs with tubercle (5–8 subequal arms) with or overtopped by larger spreading, rarely apparently stalked fascicled hairs with basal tubercle or \pm stalked (12–16 often unequal arms); *on leaves above* sparse or scattered and wearing off soon, with subequal erect fascicled hairs (1 or 2, rarely 3 arms on flanks, usually subequal and 0.2–0.4 mm long); *on leaves below* sparse or scattered, with mainly larger recurved fascicled hairs often with basal tubercle (5–8 subequal arms), occasionally overtopped, mainly on the central vein, by usually apparently stalked, very large spreading to recurved fascicled hairs (9–18 often unequal arms); *on bracts above* sparse to dense, with spreading to antrorse subequal fascicled hairs, below sparse to scattered, with small to few larger, often tuberculate (rarely stalked) spreading fascicled hairs; *on outer calyx lobes* outside scattered to sparse, with mainly large apparently stalked fascicled (5–12 often unequally long arms), over rarely few scattered small fascicled hairs without basal tubercle (3–5 subequal arms), inside sparse to dense, with antrorse \pm appressed fascicled hairs (2–4 subequal branches); *on inner calyx lobes* outside usually with a dense cover of small almost appressed fascicled hairs without tubercle (3–6 subequal or unequal reflexed arms) overtopped by scattered larger spreading fascicled hairs with basal tubercle or apparent stalk (8–15 arms), sometimes absent on innermost lobes, inside glabrous, shiny. *Leaves* with short, or without, tuft of hairs in the axils; *petiole* 0.2–0.5 mm long; *lamina* linear to oblong-lanceolate, (3.6–) 4.5–7 (–8.5) \times (0.5–) 0.6–1.4 (–1.8) mm, bluntly acute becoming obtuse, abruptly constricted into petiole, above scarcely depressed along the central vein and sparsely pilose, below with broad central vein flush with or slightly bulging above abutting revolute margins and sparsely hirsute. *Flowers* single, stalked and usually obviously leaf-opposed on distal terminal and axillary branches; *stalk* (peduncle and pedicel) (4.4–) 5–15 (–24.5) mm long; *bracts* on upper third of stalk, linear-elliptic or –lanceolate, (4.3–) 5–6 (–6.5) mm long, incurved, usually pointed. *Calyx lobes* unequally long; *outer calyx lobes* lanceolate, (5.1–) 5.5–6.5 (–7.3) \times (2.2–) 2.3–2.4 (–2.6) mm long, usually longer than inner lobes, acute or usually drawn into a point, ridged towards the apex, outside coarsely but sparsely hirsute becoming lumpy when dry, inside pubescent towards the apex; *inner calyx lobes* elliptic-oblong, rarely lanceolate-oblong, (4.4–) 5–5.8 (–6.2) \times (2.5–) 2.6–2.8 (–3) mm, obtuse or mucronate, \pm ridged from base to apex, outside sparsely tomentose and sometimes shortly bristled along ridge, inside glabrous, shiny. *Petals* obovate, 6–11 mm long, scarcely emarginate. *Stamens* 6 or 7 (–10) in dorsal cluster; *filaments* \pm basally connate; *anthers* obloid,

1.6–1.9 mm long, abruptly constricted above and below. *Pistils* 2; ovaries broadly obovoid and \pm laterally compressed, with – ovules, tomentose, style attached to the dorsal side, erect on either side of the anthers with stigmas well above the anthers. *Fruits* recurved. *Seeds* obovoid to comma-shaped, 2.4–2.6 \times 1.7–1.8 mm, black or brown; aril cup-shaped with fleshy base.

Distribution. Two subspecies, both of them confined to South Australia, one (subsp. *glebosa*) from the Mt Lofty Ranges and the other (subsp. *oblonga*) from Kangaroo Island.

Diagnostic features. This species is easily distinguished from *H. australis* by its apparently stalked fascicled hairs (cf. fig. 1C & D) mainly on the central vein on the abaxial surface of the leaves and particularly the outer surface of the outer calyx lobes. The tissues below the hairs do not shrink as much as the glabrous areas in between, so that the leaves and calyx attain a lumpy appearance in dried material. The hairs on the leaf upper surface are few and scattered, many of them with [only] 1 or 2 arms, 0.2–0.4 mm long.

Notes. The apparently stalked hairs of this species are very large fascicled hairs with a distinct tubercle which is also visible on fresh material but becomes elevated on a hump due to uneven drying of the tissues below (cf. Fig. 1C & D). Populations of *H. glebosa* show variation in hair size and density particularly of the calyx lobes.

In the Mt Lofty area, the hairs of plants from Tea Tree Gully populations are usually smaller, but they are similarly scattered as on plants from the rest of the region. In addition to being smaller, particularly on the upper leaf surface, the hairs of the Tea Tree Gully populations are easily distinguished by only one or two arms in comparison to those with up to five arms in populations of *H. australis* from the Para Wirra area to the Barossa Valley. Similar shorter but very dense hairs with more arms are found on specimens of the closely related species, *H. australis*, from the South-Eastern Region (SE) of South Australia and southern Victoria.

Etymology. ‘Glebosa’, Latin for ‘lumpy’, alludes to the uneven surface of particularly the outer calyx lobes and is accentuated when dried which leads to a “bumpy” appearance (see above).

H. glebosa subsp. *glebosa*

Hibbertia stricta var. *canescens* Benth. Fl. Austral. 1: 27 (1863), p.p.; J.M.Black, Fl. S. Austral. 3: 387 (1926), p.p.; ed. 2, 3: 576 (1952), p.p. (see note below).

Hibbertia stricta var. *stricta* auct. non (R.Br. ex DC.) F.Muell.: J.M.Black, Trans. & Proc. Roy. Soc. South Australia 49: 274 (1925), p.p.; Fl. S. Austral. 3: 387 (1926), p.p.; ed. 2, 3: 576 (1952), p.p.

Hibbertia australis auct. non N.A.Wakef.: N.A.Wakef. Victorian Naturalist 72: 121 (1955), p.p.; H.Eichler, Suppl. J.M.Black’s Fl. S. Austral. 226 (1965), p.p. (only as to specimens from SL).

Hibbertia stricta auct. non (R.Br. ex DC.) F.Muell.: J.M.Black, Fl. S. Austral. 3: 387 (1926), p.p.; ed. 2, 3:

576 (1952), p.p.; Hoogland, Kew Bull. 29: 155 (1974), p.p.; Jessop in Jessop & Toelken, Fl. S. Austral. 1: 358 (1986), p.p.

Shrubs spreading to decumbent. *Leaves* (4.2–) 5–7 (–8.5) × (0.5–) 0.6–0.7 (–0.8) mm or 7–10 (–12) times longer than broad. *Bracts* 5.5–6 (–6.8) mm long. *Outer calyx lobes* usually drawn into a point apically and longer than inner ones. *Flowering*: mainly August–December. **Fig. 1C.**

Distribution and ecology. Locally frequent on sandy clay or loam in open woodland, but confined to Mount Lofty Ranges, South Australia (SL).

Conservation status. Locally common and represented in several conservation reserves in the Mt Lofty Ranges.

Variation. Although plants of subsp. *glebosa* have slightly smaller hairs in the populations to the north-east of Adelaide in areas such as Tea Tree Gully, the hairs are sparse and those on the upper leaf surface have one or two, rarely three arms. In addition, the dried specimens show the typical humps on which the large, often apparently stalked fascicled hairs are situated.

Notes. Bentham's concept of the *H. australis* group can only be deduced from his description of *H. stricta* var. *canescens*, as he did not cite any specimens directly referable to this species complex. Whether he had seen a specimen of *H. glebosa* is unknown. The following annotation by Bentham on a specimen of *H. australis* (R. Brown [J.J. Bennett 4872] Arthurs Seat (BM!)) could be indicative of the confused concept of *H. stricta* held at the time: "Hibbertia (Pleurandra) considered by Mueller as one of the varieties of *H. stricta* but seems to me a variety of his *H. humifusa*".

The ambiguity increased as Black (1926, 1952) obviously recognised that the floral stalk length varied as he noted under *H. stricta*: "When the peduncles are long there is usually a small leafy bract some distance below the calyx." However, he never used this character to divide *H. stricta*, but seems to have heavily relied on the denseness of the tomentum. He included specimens of *H. glebosa* and *H. australis* as well as some forms of *H. devitata* in his interpretation of *H. stricta* var. *glabriuscula*, while other more hairy specimens he studied were identified in his handwriting as *H. stricta* var. *canescens* (e.g. J.M. Black s.n., 28.viii.1920). But his cited distribution range of the latter variety, "Murray lands and Flinders Range" shows that he also included here specimens of *H. crinita* Toelken (Toelken 2000, p.9) of the *H. sericea* group.

Selection of specimens examined (c. 75 seen)

SOUTH AUSTRALIA. **SL:** A.M. Ashby 749, Blackwood, 27.ix.1941 (AD); R. Bates 62796, Watts Gully Woodland Reserve, vi.2004 (AD); J.M. Black s.n., National Park Belair, 28.viii.1920 (AD 97044021); B.J. Blaylock 2875, Sturt Gorge Recreation Park, 19.viii.2001 (AD); B.J. Blaylock 2975, Birri Track, 12.x.2001 (AD); N.N. Donner 857B, Ansteys Hill, 14.ix.1963 (AD, CANB); R.D. Hoogland 11855, Upper Hermitage, 13.xi.1970 (AD; CANB, L – n.v.);

D.N. Kraehenbuehl 591, near Highbury Hotel, 15.viii.1962 (AD; CANB – n.v.); T.J. Smith 2162, Hope Valley Reservoir, 28.viii.1969 (AD); J.G.O. Tepper 279, Coromandel Valley, 9.xi.1881 (AD); D.J.E. Whibley 7117, Angoves Scrub, Tea Tree Gully, 8.vii.1980 (AD).

H. globosa subsp. *oblonga* (J.M. Black) Toelken, *comb. et stat. nov.*

Hibbertia stricta var. *oblonga* J.M. Black, Trans. & Proc. Roy. Soc. South Australia 49: 274 (1925); Fl. S. Austral. 3: 387 (1926); ed. 2, 3: 576 (1952) – non *H. oblongata* R.Br. ex DC., Syst. Nat. 1: 431 (1817). — **Type:** South Australia, Kangaroo Island, Ravine [des Casoars] Creek, H.H.D. Griffith s.n., x.1918 (holo.: AD; iso.: K, MEL – n.v.).

Hibbertia sp. *Humilis* (H.R. Toelken 9196) Toelken in W.R. Barker et al., J. Adelaide Bot. Gard. Suppl. 1: 50 (2005).

Hibbertia australis auctt. non N.A. Wakef.: N.A. Wakef., Victorian Naturalist 72: 121 (1955), p.p.; H. Eichler, Suppl. J.M. Black's Fl. S. Austral. 226 (1965), p.p. (only as to specimens from KI).

Hibbertia stricta auctt. non (R.Br. ex DC) F. Muell.: Hoogland, Kew Bull. 29: 155 (1974), p.p.; Jessop in Jessop & Toelken, Fl. S. Austral. 1: 358 (1986), p.p.

Shrubs with rigid spreading branches. *Leaves* 3.5–4.5 (–5.9) × 1–1.5 (–1.9) mm or 3–5 times longer than broad. *Bracts* 4.3–5 (–5.2) mm long. *Outer calyx lobes* acute and more or less as long as inner ones. *Flowering*: September, October.

Distribution and ecology. Confined to the western end of Kangaroo Island where it is very local on sandy clay or laterite near swamps or creeks, or in ravines in open woodland.

Conservation status. Locally frequent (Toelken 9196), but conserved in Flinders Chase National Park.

Notes. The apparently stalked fascicled hairs of subsp. *oblonga* are often not as pronounced as in the case of subsp. *glebosa*, but it is nevertheless clear from the overall vestiture that subsp. *oblonga* must be connected to *H. glebosa* rather than the widespread *H. australis*.

The leaf-opposed flowers are clearly visible in subsp. *oblonga*, while their position is not always clear in subsp. *glebosa* as its branches are often considerably fascicled below the flowers.

Typification. Wakefield (1955) acknowledged that var. *oblonga* of Black (1925) was different but did not elevate it to species level "firstly because Black's type material is abnormally small, and secondly to avoid confusion with the epithet *oblongata* which is in use in the genus". Although the type specimen is small, subsp. *oblonga* is easily distinguished by the characteristics used here. Other specimens, such as Toelken 9196 from a similar locality, illustrate a greater range of variation.

Specimens examined

SOUTH AUSTRALIA. **KI:** B.M. Overton 2569, Berrymans Road, W North Coast Road, 26.ix.1995 (AD); H.R. Toelken 9196, along Shackle Road, upper Ravine des Casoars, 15.x.1997 (B, CANB, K, MEL, MO, PERTH).

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New taxa and typifications in *Indigofera* (Fabaceae) for South Australia

Peter G. Wilson^a & Ross Rowe^{a, b}

^aNational Herbarium of New South Wales, Royal Botanic Gardens,
Mrs Macquaries Road, Sydney, New South Wales 2000
Email: peter.wilson@rbgsyd.nsw.gov.au

^bPresent address: Department of the Environment, Water, Heritage and the Arts,
GPO Box 787, Canberra, Australian Capital Territory 2601

Abstract

As a precursor to the revised *Flora of South Australia*, one new species of *Indigofera*, *I. cornuligera* Peter G. Wilson & Rowe (with two subspecies: subsp. *cornuligera* and subsp. *flindersensis* Peter G. Wilson & Rowe), and one new subspecies of *I. australis* Willd. (subsp. *hesperia* Peter G. Wilson & Rowe), are described. Neotypes are designated for three accepted species and lectotypes for seven synonyms.

Key words: Fabaceae, Indigoferae, *Indigofera*, nomenclature, taxonomy, South Australia.

Introduction

The current *Flora of South Australia*, published in 1986, is being updated. As a prelude to a revised treatment of the tribe Indigoferae (Fabaceae) in this new edition, we are taking the opportunity to describe three new taxa in *Indigofera* and typify a number of others.

A new subspecies in *Indigofera australis* Willd.

Indigofera australis is a very variable species, particularly in New South Wales and Queensland. Leaflet numbers and sizes, habit and stem morphology (ribbed vs. ± terete) vary geographically, usually without any readily discernible pattern, although a form found on hills in western New South Wales that usually has 7–9 rather long, narrow leaflets would be worthy of further study. However, the populations found in Western Australia and the western part of South Australia are morphologically relatively uniform. Plants in these populations are most readily distinguishable by their smaller, more numerous, leaflets and we here recognise them as a taxon at the rank of subspecies.

Indigofera australis Willd.

Sp. Pl. 3: 1235 (1802). — *Anila australis* (Willd.) Kuntze, Revis. Gen. Pl. 2: 938 (1891). — **Type citation:** ‘*Habitat* in Nova Hollandia? h (v.v.)’. **Type:** Probably not extant. Willdenow cites a living plant in his protologue (presumably one in cultivation in Berlin). There are two specimens in the Willdenow herbarium, apparently sent by Wendland, which match the protologue very well; we have chosen one of these as neotype. **Neotype (designated here):** specimen with immature fruit labelled ‘Ind. australis l.’ (B–Willd., photo NSW [IDC microfiche, specimen no. 13904]).

Indigofera sylvatica Sieber ex Spreng., Syst. Veg. 3: 278 (1826). — **Type citation:** ‘Nov. Holl.’. Sprengel does not indicate a type, but de Candolle (1825: 226) cites the Sieber manuscript name as follows: ‘*I. sylvatica* Sieb. pl. exs. nov.-holl. n. 379.’ Sprengel’s herbarium at B is no longer extant, so we choose de Candolle’s specimen as lectotype. **Lectotype (designated here):** *FW.Sieber Fl. Nov. Holl. 379* (G-DC [IDC microfiche 800/11]). **Islectotypes:** BM n.v., K, MEL, NSW.

Indigofera angulata Lindl., Bot. Reg. 12: t. 991 (July 1826), nom. illeg. non Rottler ex Spreng., Syst. Veg. 3: 277. 1826 (Jan.–Mar. 1826). — *Indigofera lindleyana* Spreng. ex Steud., Nomencl. Bot. ed. 2, 1: 807 (1841), nom. illeg. — **Type citation:** ‘Communicated in April last, by Mr. Whitney, of the Fulham Nursery, where it had been raised from New Holland seeds, received ... from Mr. Joseph Thomas.’ Lindley’s description is based on this cultivated plant but he does make some comparison with other specimens. There appears to be no extant specimen of this cultivated plant, so it seems prudent to choose the illustration as lectotype. **Lectotype (designated here):** Bot. Reg. 12: t. 991 (1826).

Note. The name *I. lindleyana* was given by Steudel (but attributed to Sprengel) apparently as a new name for the illegitimate *I. angulata*. The name is, however, itself illegitimate since Steudel cites the validly published name *I. sylvatica* as a synonym.

Key to subspecies

Leaves usually with 7–15 leaflets; leaflets usually 10–40 mm long; petiole usually 6–15 mm long; stipule-bases not swollen by masses of multicellular hairs; peduncle usually 10–20 mm long subsp. *australis*
Leaves usually with 17–25 leaflets; leaflets usually 5–10 mm long; petiole usually 3–6 mm long; stipules usually with bases swollen by masses of multicellular hairs; peduncle usually 4–7 mm long subsp. *hesperia*

Indigofera australis* Willd. subsp. *australis*Indigofera australis* Willd. var. *australis**Indigofera australis* var. *gracilis* DC., Prodr. 2: 226 (1825).

— **Type citation:** ‘*h* in Novae-Hollandiae ora orientali. *I. australis* Sieb! pl. exs. nov.-holl. n. 380. (v.s.)’. De Candolle cites two specimens, one collected by Sieber and the other by an unnamed collector. We have chosen the latter as lectotype. **Lectotype (designated here):** Nouvelle Hollande, côte orient. Musée de Paris 1821 (G-DC [IDC microfiche 800/11]). **Residual syntype:** F.W.Sieber Fl. Nov. Holl. 380 (G-DC [NSW, IDC microfiche 800/11]). **Isosyntypes:** BM n.v., K, MEL, NSW, W.

Indigofera australis var. *angulata* Benth., Fl. Austral. 2: 200 (1864). — **Type:** not specified. Bentham probably based this variety on Lindley’s illegitimate name (see above) but this is not expressly indicated.

Indigofera australis var. *minor* Benth., Fl. Austral. 2: 200 (1864). — **Type citation:** ‘Chiefly in the interior of N.S. Wales and S. Australia, on the Lachlan and Darling, etc., and northward to Clarence river’. Bentham gave a broad geographic range for this variety but we could find no specimen annotated with this varietal epithet. We have chosen as lectotype a specimen that best matches the protologue; this is one of a number from the Clarence River area that was seen by Bentham. It is possible that this suite of specimens is taken from an intergrade population between *I. australis* and *I. adesmiifolia* A.Gray. **Lectotype (designated here):** Clarence River, Dr Beckler (MEL 586484). **Isolectotypes:** MEL 585746, 584685.

Shrub, 0.5–2 m high; young stems ridged to terete. Leaves pinnate, (3–) 7–15 (–21) leaflets; stipules 1–2.5 (–5) mm long, glabrescent; petiole (3.5–) 6–15 (–19) mm long; rachis furrowed, with multicellular hairs between leaflet pairs absent to moderately dense (rarely dense), conspicuous to inconspicuous, red to brown, club-shaped. Leaflets opposite (sometimes a few alternate); stipellae generally absent, rarely 0.3–0.6 mm long; lamina ovate to elliptical or oblong, (5–) 10–40 (–63) mm long, (2.5–) 5–10 (–23) mm wide; upper surface green, glabrous or hairs sparse, rarely moderately dense; lower surface green (generally paler than above), glabrous or with sparse, rarely moderately dense, appressed hairs; apex acute, emarginate or obtuse and mucronate, veins not prominent. Inflorescences (13–) 30–100 (–220) mm long, usually longer than the leaves; peduncle (1–) 10–20 (–33) mm long; bracts triangular, 0.5–1 (–2) mm long; flowers pink to purple; pedicel (1.5–) 2–4 (–5.5) mm long. Calyx (1–) 1.5–3 mm long, with unequal to subequal lobes shorter than the length of the tube, sparsely hairy with white to brown hairs. Standard purple or pink, ovate, obovate or orbicular, 6–8 (–10.6) mm high, 6.5–9 mm wide. Wings narrowly obovate, 6.5–11 mm long, 2.5–3.5 mm wide. Keel 6.5–10 mm long, 2.2–3 mm deep, apex rounded to acute; lateral pockets 0.8–1.5 mm long; hairs sparse to moderately dense, hyaline, along the bottom. Staminal tube 4–6.5 mm long. Ovary usually glabrous. Pod ascending to descending, (13–) 30–45 (–52) mm long, 2.5–4 mm deep, brown, usually glabrous but sometimes with scattered, appressed hairs; apex shortly pointed; endocarp spotted. Seed (4–) 8–10 (–12) per fruit.

Distribution & habitat. Queensland, South Australia, NSW (incl. A.C.T.), Victoria, and Tasmania: wide range of sites generally on loamy soils on mountain slopes and ranges.

Selected specimens examined (S.A. only)

SOUTH AUSTRALIA. **Lake Eyre:** Brindana Gorge, 18 Oct. 1987, E.C.Foster 300 (AD). **Flinders Ranges:** Creekline, Paralana Springs, 24 Aug. 1968, Symon 6023 (AD, CANB); Arcoona Creek Camp site, Gammon Range, 23 Aug. 1956, Lothian 2034 (AD, NSW). **Eastern:** Bumbumie Springs, Koonamore, 24 Aug. 1930, Yardley s.n. (AD 98434988); Cathedral Rock, c. 20 km N of Olary, 26 Aug. 1972, Kuchel 3093 (AD). **Southern Lofty:** Torrens Gorge, Central Hills, 8 Dec. 1977, Spooner 5653 (AD, MEL); near Victor Harbour off Range Road, 12 Nov. 1968, Hunt 2871 (AD, BRI). **Murray:** Keyneton, Sep. 1927, coll. unknown (AD 97722021). **Northern Lofty:** Brown Hills, s.dat., Mueller s.n. (MEL 586511). **South-eastern:** Hundred of Caroline Sn 372, Honeysuckle Flat, Caroline Forest Reserve, 26 Sep. 1984, Dickson 71 (MEL, HO, NSW); Comaam, c. 20 km N of Penola, 20 Sep. 1964, Hunt 2145 (AD).

Indigofera australis* Willd. subsp. *hesperia* Peter*G.Wilson & Rowe, subsp. nov.**

Folia plerumque 17–25-foliolata, foliolis vulgo 5–10 mm longis et petiolo 3–6 mm longo; stipulae plerumque basi strumosae trichomatibus multicellularibus aggregatis; pedunculo plerumque 4–7 mm longo.

Holotype: Kalbarri, upper banks of the Murchison River, 22 Sep. 1991, Peter G.Wilson 1219 & R.Rowe (NSW). **Isotypes:** AD, PERTH.

Indigofera ervoides Meisn. in Lehmann, Pl. Preiss. 1: 88 (1844).

— **Type citation:** ‘In umbrosis inter fragmenta rupium montis Mathilda, alt. 975 ped. (York) d. 11. Sept. 1939. Herb. Preiss. No. 1067.’ **Holotype:** 11 Sep. 1839, L.Preiss 1067 (LD, photo). **Isotype:** MEL.

Indigofera australis var. *angulata* Benth., Fl. Austral. 2: 200 (1864), pro parte quoad ‘Drummond and Preiss’s W. Australian specimens.’

Indigofera australis sensu Ker Gawl., Bot. Reg. t. 386 (1819).

Shrub, 0.3–1.5 (–2) m high; young stems ridged. Leaves pinnate, (7–) 17–25 leaflets; stipules generally with bases enlarged by dense masses of multicellular hairs, 2.5–4 (–5.5) mm long, pubescent or glabrescent, swollen bases often persistent; petiole 3–6 (–10) mm long; rachis furrowed, multicellular hairs between leaflet pairs moderately dense to dense, conspicuous or inconspicuous, red to brown, club-shaped. Leaflets opposite; stipellae absent or inconspicuous, 0.2 mm long; lamina obovate, (3–) 5–10 (–20) mm long, (2–) 2.5–4.5 (–6.5) mm wide; upper surface green, glabrous; lower surface green with sparse, appressed hairs; apex obtuse or emarginate; veins not prominent. Inflorescences (5–) 20–70 (–95) mm long, shorter to longer than leaves; peduncle (2–) 4–7 (–10) mm long; bracts triangular, 0.5–1.5 (–3) mm long; flowers pink to purple; pedicel 1.5–4 mm long. Calyx 1.5–3 mm long, with unequal to subequal lobes shorter than the length of the tube, clothed with sparse, brown, appressed hairs. Standard purple to pink, ovate to orbicular, 6.5–7.5 mm

high, 5.5–7.5 mm wide. Wings narrowly obovate to spatulate, 6–8 mm long, 1.7–3 mm wide. Keel (5.5–) 6–7.5 mm long, 2–2.7 mm deep; apex acute to rounded; lateral pockets 0.8–1.3 mm long; hairs sparse, hyaline to white, along the bottom and margin ciliate. Staminal tube 4–4.8 mm long. Ovary glabrous to moderately hairy. Pod descending or rarely ascending, terete, (17–) 25–40 mm long, 2–3 mm deep, brown, glabrescent or tomentose; hairs very sparse, appressed; apex shortly pointed; endocarp spotted. Seed (4–) 8–10 (–11) per fruit.

Notes. In contrast with subsp. *australis*, this taxon is relatively uniform in morphology and is most readily distinguished by the smaller, more numerous leaflets. The two subspecies do intergrade in South Australia where their ranges overlap (see notes below). The epithet is an adjective that is a latinised form of the Greek *hesperos* meaning ‘pertaining to the evening’ or ‘west’, a reference to this taxon’s distribution in the western half of the continent.

Distribution and habitat. Western Australia and South Australia, where it grows on a variety of generally loamy soils associated with rocky hills and mountain ranges.

Selected specimens examined

SOUTH AUSTRALIA. **Gairdner-Torrens:** near Glyde Hill outstation, c. 15 km N of Lake Everard Homestead, 30 Sep. 1972, *E.N.S. Jackson 2131* (AD, MEL, CANB). **Flinders Ranges:** creek along W side of Yowambulla Peak, 9 Aug. 1974, *N.N. Donner 5025* (AD); Port Germein Gorge, c. 10 km E of Port Germein township, 29 Aug. 1967, *D.J.E. Whibley 2042* (AD); Black Range, southern side of Mambray Creek, Mt Remarkable National Park, 7 Jul. 1974, *D.J.E. Whibley 4318* (AD). **Eyre Peninsula:** Hiltaba Station, c. 5 km E of Hiltaba Homestead, 3 Sep. 1975, *B.J. Blaylock 1885* (AD, E); Roopena Station, W slope of Mt Whyalla, 12 Aug. 1969, *A.E. Orchard 2094* (AD). **Northern Lofty:** Wirrabara Forest Reserve, 6 Dec. 1984, *H.P. Vonow 180* (AD).

WESTERN AUSTRALIA. **Avon:** Mt Stirling [near Kellerberrin], Jul. 1941, *C.A. Gardner s.n.* (PERTH). **Eyre:** Mt Ragged, 1890, *Miss Brooke s.n.* (MEL 586707); W of Hamersley Range, 3 miles from Phillips River Crossing, 28 Aug. 1965, *E. Wittwer 439* (PERTH). **Coolgardie:** 2.3 km S of Symmonds Hill outcamp, Fraser Range Station, 3 Sep. 1968, *G.J. Keighery 3096* (PERTH). **Irwin:** 22.6 km SE of Mingenew & 3 km E of Yandanooka at Enokurra Rocks, 6 Oct. 1995, *A.A. Mitchell 4103* (NSW, PERTH). **Roe:** Peak Charles walking track, about 100 m from carpark, 16 Oct. 1997, *P.G. Wilson 1392*, *N. Lam & E.A. Brown* (NSW, AD, PERTH).

Indigofera australis subsp. *australis* – subsp. *hesperia* intergrades

Plants with features intermediate between the two subspecies occur where their ranges meet. The vast majority of intergrade specimens have been collected in the Mt Remarkable area and along the western edge of the South Flinders Ranges.

Selected specimens examined

SOUTH AUSTRALIA. **Flinders Ranges:** Mt Aleck, Elder Range, NW of Hawker, 28 Sep. 1981, *P.E. Corrick 669* (AD, MEL); foot of Mt Remarkable, 10 Oct. 1970, *B. Copley 3198*

(AD); Port Germein Gorge, 18 Sep. 1960, *R. Filson 3147* (AD, BRI, CANB, MEL); inner slope of wall of Pound, Wilpena, 8 Sep. 1961, *D.E. Symon 1427* (AD); Brachina Gorge, Oraparinna National Park, 18 Sep. 1971, *J.Z. Weber 2627* (AD). **Northern Lofty:** Wirrabara, Oct. 1882, *J.E. Brown* (AD).

New typifications

Indigofera basedowii E. Pritzel

Repert. Spec. Nov. Regni Veg. 15: 356 (1918). — **Holotype:** Central Australia, 1903, *H. Basedow 33* (B, destroyed). **Neotype (designated here):** Northern Territory: Kings Canyon, George Gill Range, 27 Aug. 1980, *J.R. Maconochie 2485* (DNA). **Isonotypes:** CANB, BRI.

Notes. The type at B is no longer extant (fide H. Ern, in litt. 1984). As there do not appear to be any duplicates of *Basedow 33*, a neotype has been designated. The original description is somewhat in conflict with the morphology of herbarium specimens. The main features of habit, indumentum and leaflet number are in agreement with the protologue and seem unambiguously to apply to this taxon but the dimensions given for the calyx and peduncle are markedly different. In the case of the peduncle, the possible explanations for the length given (8–12 cm) are either that it includes the lower portion of the inflorescence axis after the flowers have fallen, all of which has been interpreted as peduncle, or that the measurement should have been in millimetres. The case of the calyx, however, is a mystery since a calyx 6–8 mm long with lobes c. 5 mm long is found only in *I. hirsuta*, a species which is greatly at variance with the protologue in indumentum and flower colour. Specimens of the related species *I. longibractea* from near Ernabella do have a calyx that approaches these dimensions but the number and size of the leaflets in this taxon are also at variance with the protologue. The neotype has been chosen to match the protologue as closely as possible and to preserve current usage but does not come from the area suggested earlier (Wilson 1987: 121), between Mount Chandler and Moorilyanna Well. Existing specimens from this general area have leaflets that differ in size or number from those described in the protologue.

Distribution and habitat. Northern Territory and South Australia: found on coarse gravel or sand, in skeletal soils of rocky granite, quartz and sandstone hills, on ridges, in creek beds or on flats at the base of hills.

Indigofera colutea (Burm.f.) Merr.

Philipp. J. Sci. 19: 355 (1921). — *Galega colutea* Burm. f., Fl. Indica: 172 (1768). — **Holotype** (see Gillett 1958: 66–67): Plukenet, Phytographia t. 166, f. 3 (1691).

Indigofera viscosa Lam., Encycl. 3: 247 (1789). — *Anila viscosa* (Lam.) Kuntze, Revis. Gen. Pl. 2: 940 (1891). — **Holotype** (see Gillett 1971: 268): specimen from a cultivated plant of unknown origin (P).

Indigofera seticulosa Harv., Fl. Cap. 2: 196 (1862). — **Type citation:** ‘HAB. Uncertain, Armstrong. (Herb. Hooker)’. **Holotype** (see Gillett 1958: 65): Australia: *J.W. Armstrong 385* (K).

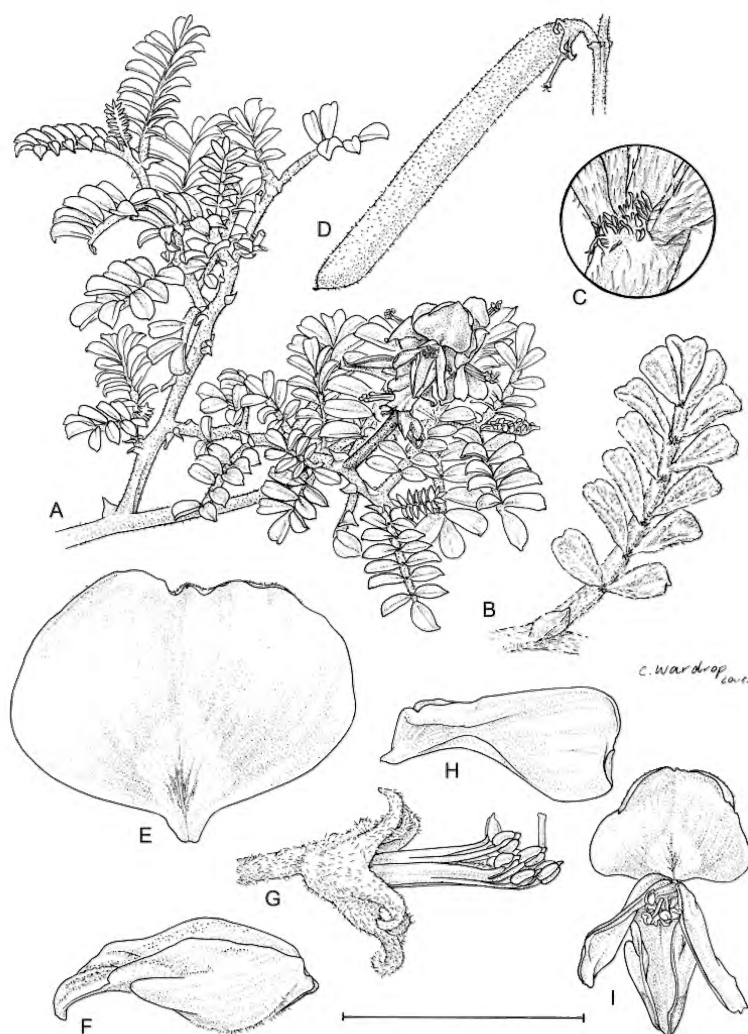


Fig. 1. *Indigofera cornuligera* subsp. *flindersensis*. A habit; B leaf; C detail of multicellular hairs on leaf rachis; D fruit; E standard; F keel; G lateral view of calyx and androecium; H wing; I flower. Scale bar: A 30 mm; B 10 mm; C–D 2 mm; E–I 6 mm. — A Wilson 796 & Rowe; B, E–I Wilson 824 & Rowe; C Wilson 795 & Rowe; D Lothian 3090.

Indigofera inconspicua Domin, Biblioth. Bot. 89 (3): 189 (1926). — **Type citation:** 'Gladstone, A. Dietrich No. 612; s.l., A. Dietrich No. 1375'. **Lectotype (designated here):** Queensland: Gladstone, [Feb 1865], A. Dietrich No. 612 (PR 52711, 52712). **Isolectotypes:** MEL 586363, HBG.

Notes. We have lectotypified Domin's species, *I. inconspicua*, by the only specimen he cited unequivocally. The second specimen cited, as 's.l., A. Dietrich No. 1375', is also listed under Domin's entry for *I. viscosa* (= *I. colutea*). The lectotype at PR now consists of

two sheets, one with two pieces of plant and one with a single piece. The latter sheet also has a hand-written draft of Domin's description attached.

Distribution and habitat. In South Australia, this species occurs only in the north and north-east. It is widely distributed in Queensland, the Northern Territory and the north-western parts of Western Australia, but is only found in a limited area of New South Wales adjacent to the Queensland border. It is recorded from sand dunes, grassy plains, roadsides or in open forest or woodland on

soils derived from a wide range of substrates. Although presumably a native species (it was collected by Banks and Solander at Endeavour River), it grows readily in disturbed sites and is now considered to be a weed in some parts of Australia (Lazarides et al. 1997). It also occurs in Africa, Arabia to India, Sri Lanka, Burma, Thailand, Vietnam, Indonesia and New Guinea.

Indigofera helmsii Peter G. Wilson

J. Adelaide Bot. Gard. 10: 119 (1987). — *I. uncinata* Ewart & L.R. Kerr, Proc. Roy. Soc. Victoria, n.s. 39: 3, fig. 2 (1926), nom. illeg. nec G. Don, Gen. hist. 2: 208 (1832), nec Roxb., Fl. ind. ed. 1832, 3: 382 (1832). — **Lectotype** (see Wilson 1987): South Australia: Mt Watson near Birksgate Range (Camp 17, Elder Exploring Expedition), 8 Jul. 1891, *R. Helms s.n.* (AD 97310107). **Probable isolectotype**: NSW.

Indigofera brevidens var. *uncinata* Benth., Fl. Austral. 2: 201 (1864). — **Type**: none cited. **Lectotype (designated here)**: 'Indigofera brevidens var. stipulis uncinatis McDoual [sic] Stuart's Expedition' (K, ex herbarium Hookerianum, lower right-hand element).

Indigofera uncinata var. *minor* Ewart & L.R. Kerr, Proc. Roy. Soc. Victoria, n.s. 39: 3 (1926). — **Type citation**: 'Hastings River, Dr. Beckler; Barrier Range, Dr. Beckler, 1861; Gascoyne River, W.A. J. Forrest, 1882'. **Lectotype (designated here)**: Towards the Barrier Range, 2 Feb. 1861, *Beckler s.n.* (MEL 586326, lowermost element).

Notes. We have chosen as lectotype of *I. brevidens* var. *uncinata* Benth. the only specimen with sharp, recurved stipules. As pointed out by Wilson (1987), Ewart and Kerr did not explicitly base their name *I. uncinata* on Bentham's varietal name so the types of the two taxa are different.

Distribution & habitat. Recorded from the Northern Territory, Western Australia, South Australia and New South Wales. The species is known only from a single area in Western Australia and from a limited area in N.S.W. This species is quite rare in N.S.W. and has only recently (May 2003) been rediscovered in Mutawintji National Park, the likely site of Beckler's 'towards the Barrier Range' collection cited above. Hermann Beckler (1828–1914), was appointed doctor and botanist on the Victorian Exploring Expedition (the Burke and Wills Expedition) but left the expedition early, at Menindee, in October 1860.

Indigofera leucotricha E. Pritzel

Repert. Spec. Nov. Regni Veg. 15: 357 (1918). — **Type citation**: 'in Australia centrali prope Hermannsburg ad fluvium Fincke, leg. Strehlow, 1906–1908, no. 156, 220.' (B, destroyed). **Neotype (designated here)**: Northern Territory: Central South: Finke River, 1.7 km from the turn-off to Palm Valley at Hermannsburg, 17 Sep. 1990, *Peter G. Wilson 720 & R. Rowe* (NSW). **Isonotype**: DNA. *Indigofera lasiantha* F. Muell., New S. Wales – Parl. Pap. – Votes & Proc. Legis. Assembly 2 (159-A): 6 (1859), nom. illeg. non Desv., Ann. Sci. Nat. (Paris) 9: 410 (1826). **Holotype**: Coopers Creek [1858], *A.C. Gregory s.n.* (MEL 585991).

Notes. The syntypes at B were apparently destroyed during the war (fide H. Ern, in litt. 1984) and a neotype

has been designated. The neotype is a collection from near the type locality, where this species is very common.

Distribution & habitat: This species is relatively common, but localised, in the Northern Territory and in the Gregory North and Gregory South districts of Queensland. In South Australia it is only known from ranges immediately to the west of the Simpson Desert (Lake Eyre region). References in the *Flora of South Australia* (Weber 1986) to *Indigofera leucotricha* occurring outside the Lake Eyre region do not apply to this species. Plants from other populations, which had been included in this broad species concept, are described below as a separate taxon.

Selected specimens examined (S.A. only)

SOUTH AUSTRALIA. **Lake Eyre:** Nilpinna homestead, 6 Jun. 1979, *Badman 206* (AD); Peake, 1882, *Chandler s.n.* (AD, MEL 585989); c. 40 km north of William Creek, 31 Jul. 1968, *Lothian 4959* (AD); creek within 8 km of Mt Attaherrikanna, 23 Sep. 1974, *Symon 9265* (AD, CANB, NSW).

The new species, *I. cornuligera*

A new species, *I. cornuligera*, is recognised from amongst those specimens referred to *Indigofera leucotricha* in the previous version of the *Flora*. This species is distinct from *I. leucotricha* and we recognise two subspecies that are geographically separate from each other. Specimens from the North-Western region of the state are referable to subsp. *cornuligera* and those from the Flinders Ranges to subsp. *flindersensis*. These two new taxa belong to a group of apparently related species with a distribution extending from western Queensland through central Australia and as far west as the Pilbara. They all have some degree of thickening of the stipule bases.

Key to distinguish *I. leucotricha* and *I. cornuligera*

Leaflets white in appearance, with dense, somewhat spreading hairs; stipules sometimes persistent but never with strongly thickened bases *I. leucotricha*
 Leaflets greenish to grey, usually with moderately dense, appressed hairs; stipules with distinctly thickened, persistent bases *I. cornuligera*

Indigofera cornuligera Peter G. Wilson & Rowe, sp. nov.

Frutex ad 1.25 m. altus internodiis comparate brevibus, stipulis atque bracteis inflorescentiae basin versus incrassatis. Folia pinnata foliolis plerumque 9–15, utrinque appresso-pubescentibus. Calyx pilis fuscatis indutus; lobi breves subaequales. Corolla usque ad 10 mm longa. Tubus staminalis 4.5–6.5 mm longus.

Holotype: Northern Territory: 20 km west of Mulga Park, 21 Sep. 1990, *Peter G. Wilson 768 & R. Rowe* (NSW). **Isotypes:** AD, DNA.

Indigofera A86365 MacDonnell Ranges (Albrecht et al. 1997)

Spreading to erect subshrub or shrub to 1.25 m high, with woody rootstock; young stems terete or slightly ridged, green or grey to brown, strigose with

dense to very dense, appressed and shortly spreading, equally biramous hairs. Leaves pinnate, usually with 9–15 leaflets; stipules triangular, generally distinctly thickened, 1.5–4 mm long, glabrescent to pubescent, spinescent, persistent; petiole 1–4 (–7) mm long; rachis furrowed (often only slightly), multicellular hairs between leaflet pairs sparse to dense, usually conspicuous, red to dark brown, club-shaped to pointed linear. Leaflets opposite; stipellae absent or inconspicuous; lamina obovate, usually 2–8.5 mm long, 1–5.5 mm wide; upper surface grey to green, with sparse to moderately dense appressed hairs; lower surface grey to green (generally paler than above), with moderately dense to dense appressed hairs; apex obtuse; veins not prominent. Inflorescences equal to longer than leaves; peduncle usually to c. 20 mm long; bracts triangular to ovate (sometimes thickened and persistent), usually 1–2 mm long. Calyx with subequal lobes less than or equal to the length of the tube, clothed with moderately dense to dense, dark, appressed or shortly spreading hairs. Petals to c. 9 mm long. Staminal tube mostly 4.5–6.5 mm long. Ovary moderately hairy. Pod spreading to descending, terete, brown, strigose to glabrescent; hairs sparse to dense, appressed to spreading; apex shortly pointed; endocarp spotted. Seed usually up to 10 per fruit.

Notes. The epithet is derived from the Latin *cornulum*, little horn, and *gero*, to bear or carry, and alludes to the horn-like appearance of the pairs of thickened stipules, which are well-developed in this taxon.

Key to subspecies

Flowers pink to purplish; sepals ± straight; clusters of multicellular hairs between leaflet pairs distinct, usually also scattered along the rachis subsp. *cornuligera*
 Flowers red; sepals mostly with recurved tips; clusters of multicellular hairs between leaflet pairs not strongly developed subsp. *flindersensis*

Indigofera cornuligera Peter G. Wilson & Rowe subsp. *cornuligera*

Spreading to erect subshrub or shrub, (0.2–) 0.4–1.25 m high. Leaves with (7–) 9–15 (–21) leaflets; stipules 1.5–4 mm long; petiole 1–4 (–7) mm long; multicellular hairs between leaflet pairs moderately dense to dense, conspicuous; stipellae absent or inconspicuous, 0.2–0.6 mm long. Leaflets with lamina obovate, 2.5–7 (–11) mm long, 1.5–4 (–5.5) mm wide; apex obtuse and emarginate. Inflorescences (7–) 15–50 (–85) mm long, equal to longer than leaves; peduncle (1.5–) 4–13 (–20) mm long; bracts 1–2 mm long; flowers pink to purple; pedicel 1–2 mm long. Calyx 2–4 mm long, clothed with moderately dense to dense, brown to black (rarely pale) appressed or shortly spreading hairs. Standard purple to pink, ovate to orbicular, 6.5–8.3 mm high, 6.5–9.5 mm wide. Wings spatulate, 6.5–8 mm long, 2–4.5 mm wide. Keel 7–8 mm long, 3–3.5 mm deep; apex rounded to acute; lateral pockets 0.5–1.3 mm long; hairs moderately dense to dense, hyaline to dark brown, along the bottom and at the tip; margin ciliate. Staminal tube 5–6.5 mm

long, colourless or free ends and tube pigmented. Pod (15–) 20–30 (–40) mm long, 2.5–4 (–4.5) mm deep, brown, tomentose; hairs sparse to moderately dense, appressed to shortly spreading. Seed (4–) 7–10 (–12) per fruit.

Distribution and habitat. South Australia, Western Australia and Northern Territory; found on hillsides, rocky ground, and in gorges and creek outwash areas.

Selected specimens examined.

SOUTH AUSTRALIA. **North-western:** Poondinna Transshipping, Birksgate Range, 21 Aug. 1973, *N.N. Donner 4314* (AD, DNA); Tomkinson Ranges, Dulgunia Hill, Northeastern slopes of Scarface, 4 Sep. 1978, *J.Z. Weber 5384* (AD, NSW); c. 1 km E of Everard Park Homestead (Mimili), 13 Sep. 1978, *D.J.E. Whibley 6902* (AD, NSW).

NORTHERN TERRITORY. **Central South:** hill above Lasseter's Cave, Hull River, 25 Aug 1973, *R.J. Chinnock 506* (AD, DNA); Mt Olga, 25 Jun. 1958, *G. Chippendale NT4669* (AD, DNA, NSW); South Bloods Range, 26 Sep. 1970, *C.R. Dunlop 1901* (DNA, NSW).

WESTERN AUSTRALIA. **Giles:** Eastern foot of Walter James Range, 24 Jul. 1967, *A.S. George 8879* (CANB, PERTH); Blackstone Range, Wingelina Nickel area, 8 Jan. 1973, *D.E. Symon 8394* (AD).

Indigofera cornuligera subsp. *flindersensis* Peter G. Wilson & Rowe, subsp. nov.

Ab subsp. *cornuligerae floribus rubris, sepalis saepe recurvatis, caespitibus pilorum in rhachidi minus effectis differt.*

Holotype: South Australia: Flinders Ranges: c. 1.2 km E of Erengunda Creek on Wirrealpa–Blinman Road, 26 Sep. 1990, *Peter G. Wilson 824 & R. Rowe* (AD).

Isotypes: K, NSW.

Erect and spreading shrub or subshrub, 0.3–1.2 m high, up to 2 m wide. Leaves with (5–) 11–15 (–19) leaflets; stipules 1.5–3.5 mm long; petiole 1–4 (–7) mm long; multicellular hairs between leaflet pairs sparse to dense, moderately conspicuous; stipellae absent. Leaflets with lamina obovate, 2–8.5 mm long, 1–6 mm wide; apex obtuse, mucronate and emarginate. Inflorescences 25–110 mm long, longer than leaves; peduncle 4–20 (–28) mm long; bracts 1.8–2.3 mm long; flowers red; pedicel 1.5–3.5 mm long. Calyx 2.5–4 (–5) mm long, clothed with dense, brown to almost black, appressed hairs. Standard red, broadly ovate or orbicular, (5–) 6–9 mm high, 7–10 mm wide. Wings narrowly obovate or spatulate, 6.5–8.5 mm long, (1.7–) 2.5–3.7 mm wide. Keel (5.5–) 6.5–9 mm long, 2.4–3.3 mm deep; apex acute or rounded; lateral pockets 1–1.7 mm long; hairs moderately dense to dense, rarely sparse, brown, along the bottom and at the tip. Staminal tube (4–) 4.5–6 mm long, free ends and tube pigmented. Pod 18–32 mm long, 2.5–3 mm deep, grey to brown, tomentose, often glabrescent; hairs sparse to dense, spreading. Seed c. 9 per fruit. **Fig. 1.**

Distribution and habitat. Restricted to the Flinders Ranges where it has been found on rocky hillsides or

in rocky creek beds on a range of substrates including shale and limestone.

Selected specimens examined.

SOUTH AUSTRALIA: **Flinders Ranges:** Freeling Heights, May 1976, *R. Bates 2026* (AD); Paralana Springs, 15 Jul. 1986, *K.A. Menkhorst s.n.* (MEL, NSW); Italowie Gorge, 25 Sep. 1990, *P.G. Wilson 795–796* & *R. Rowe* (AD, NSW).

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Australia



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NOTE

Some observations on *Salsola* L. (Chenopodiaceae) in Australia

R.J. Chinnock

State Herbarium of South Australia, P.O. Box 2732, Kent Town, South Australia 5071

E-mail: bob.chinnock@sa.gov.au

Abstract

In recent years there has been much confusion as to the correct name application for the Australian species of *Salsola* L. Prior to the late 1990's *S. kali* L. was universally applied throughout Australia but Rilke (1999) adopted the name *S. tragus* L. and more recently some authors have taken up the name *S. australis* R.Br.

Molecular studies by Hrusa & Gaskin (2008), Borger et al. (2008) and Ayers et al. (2008) confirm that *Salsola australis* is distinct from both *S. tragus* and *S. kali* so this name has been adopted for the forthcoming 5th edition of the *Flora of South Australia*.

Observation of *Salsola* populations in Western Australia and South Australia suggest that *Salsola australis* is a complex of at least six forms which require an Australian-wide molecular/systematic study to determine their status.

Keywords: Chenopodiaceae, *Salsola*, *S. australis*, *S. austroafricanus*, *S. tragus*, *S. kali*, molecular studies, observations of populations in Western Australia and South Australia

Introduction

When preparing the genera of Chenopodiaceae for the fifth edition of the *Flora of South Australia* (in prep.) a problem arose over the application of the species name for the Australian *Salsola* L. Until recently the name *S. kali* L. had been universally misapplied in state and commonwealth floras to the Australian species but when Rilke (1999) revised *Salsola* sect. *Salsola* she referred all Australian populations to *S. tragus* L., a widespread species in Eurasia and the Mediterranean regions and introduced into other areas including South Africa and North America. Furthermore, she recognised a number of subspecies in Australia applying the names subsp. *tragus*, subsp. *pontica* (Pall.) Rilke and described a new subspecies from Western Australia namely subsp. *grandiflora* Rilke. The former two subspecies occur in Eurasia and the Mediterranean respectively and the latter restricted to Australia.

In a recent study of the *S. tragus* complex in California, Hrusa & Gaskin (2008) recognised three entities in the complex, namely: *S. tragus sens. str.*, *Salsola* 'type B' and in an effort to characterise 'type B' a third entity 'type C' was also identified. Using discriminant analysis with molecular genotype sequencing, *S. tragus* and *Salsola* 'type B' were found to be morphologically distinct species and *Salsola* 'type C' was morphologically intermediate between them. Furthermore *Salsola* 'type C' contained DNA sequence genotypes that were an additive mixture of

haplotypes mostly exclusive to the tetraploid *S. tragus* and the diploid *Salsola* 'type B'. *Salsola* 'type C' was determined to be a fertile allohexaploid resulting from hybridisation between *S. tragus* and *Salsola* 'type B'.

Hrusa & Gaskin found two pre-existing names were available for their *Salsola* 'type B'. The holotype specimen of *S. kali* subsp. *austroafricana* Aellen (1938) held at Munich (M) and the lectotype (BM) of *Salsola australis* R.Br (1810) matched 'type B' closely. The fertile allohexaploid ('type C') was described as a new species, *S. ryanii* Hrusa & Gaskin. Interestingly,



Fig. 1. *Salsola australis* subsp. *Coastal*, habit — R.J.Chinnock 10246.

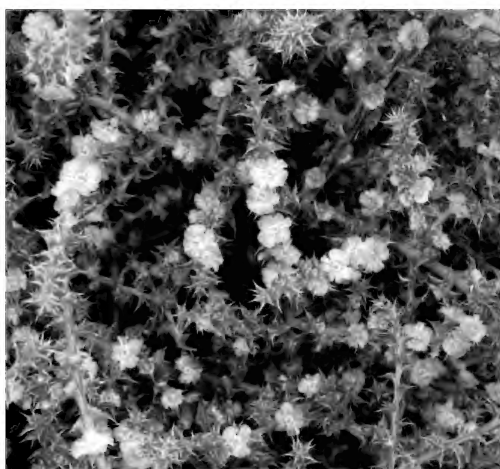


Fig. 2. *Salsola australis* subsp. *Coastal*, fruiting branches — R.J. Chinnock 10246.

another paper on the Californian tumbleweed (*Salsola* sect. *Kali*) by Ayers et al. (2009) refers to *S. kali* subsp. *austroriparian* but makes no reference to either *S. australis* or the paper by Hrusa & Gaskin (2008). Presumably this was the result of a longer delay before publication, as the Ayers paper was submitted in late 2007.

A molecular and cytological study was recently undertaken by Borger et al. (2008) on populations of *Salsola* found in the south-west of Western Australia. They studied 22 populations and recognised four genetically distinct groups that were not closely related to the *S. tragus* out-group sourced from the USA. Furthermore these groups, together with a *S. australis* sample obtained from Santa Nella, California were found to be diploid whereas *S. tragus* subsp. *tragus* was tetraploid.

Group A was identified as *S. australis* and Groups B, C and D were not classified further and could not be matched up with the descriptions of either *S. tragus* subsp. *pontica* or *S. tragus* subsp. *grandiflora* recorded for Australia by Rilke (1999). According to Borger et al. (2008) their Group D matched Robert Brown's description of *Salsola macrophylla* (collected at Thirsty Sound, Qld) This species was characterised by Brown as being an erect shrub with succulent leaves and is described as an erect woody plant.

Walsh (1996) in his discussion of *S. kali* in the *Flora of Victoria* recognised three entities in that State and although he suggested possible names that could be applied he wisely made no formal recognition of those names. According to Mr Val Stajsic, National Herbarium of Victoria (pers. comm.), two Victorian forms of *Salsola* currently filed in the National Herbarium of Victoria's collections under subsp. *tragus* and subsp. *pontica* are well defined and have different habitat



Fig. 3. *Salsola australis* subsp. *Strobilifera*, showing the fruits aggregated into cones on short lateral branches — R.J. Chinnock 10020.

preferences with one restricted to coastal or near coastal places and the other widespread in the State. The two differ significantly in colour, stem thickness and fruit structure.

I have taken the opportunity recently, since preparing the treatment of *Salsola* for the *Flora of South Australia*, of noting some of the variation seen in populations in Western Australia and South Australia and, although this is in no way intended to be a taxonomic account, my observations do support the work of Borger et al. (2008), Walsh (1996) and Stajsic (pers. comm.) in suggesting that there are a number of well defined taxa within *Salsola australis*. Although I do not know at what level these forms should be formally recognised, I have for consistency referred to them as subspecies in this paper. I have neither examined collections in other Australian herbaria nor have I consulted any type specimens so the observations given below are merely a guide to some of the variation observed.

Observations & Discussion

At least three forms of *Salsola* are known to occur in South Australia and one of these appears to be restricted to coastal or near coastal areas and may possibly be equivalent to the coastal Victorian form found in similar situations. This form, *Salsola australis* subsp. *Coastal* (R.J. Chinnock 10246), is a very dense, rigid, spinescent, fleshy shrub (Figs 1 & 2) and most probably is the typical form of *S. australis*. Robert Brown collected *S. australis* in the Nuyts Archipelago most likely on St Francis Island and all the collections from the St Francis Isles (St Francis, Dog and Fenelon Islands) held in the State Herbarium (AD) represent this form.

The recent studies by both Hrusa & Gaskin (2008) and Borger et al. (2008) suggest that the Australian populations of *Salsola* are probably endemic and not



Fig. 4. *Salsola* population on the Landor Road, WA.

referrable to *S. tragus* as was done by Rilke in 1999. The study undertaken by Borger et al., was very parochial and only covered a small area of the south west of the continent so there is a need for a detailed Australia-wide study of *Salsola* to be undertaken, combining morphology, ecology, cytology and molecular analyses, before any meaningful taxonomic sense of the genus in Australia can be achieved.

The molecular analysis of the Old World *Salsoleae* sens. lat., undertaken by Akhani et al. (2007), found that the Australian species fell within the 'Kali Clade' along with *S. kali* and *S. tragus*, and furthermore they resurrected the generic name *Kali* Miller making the combination *Kali australis* (R.Br.) Akhani & E.H. Roalson although they incorrectly cited the basionym. However the generic name *Kali* as pointed out by Paul G. Wilson is illegitimate (pers.comm., email 31 Mar. 2010), and if this group is treated as distinct from *Salsola* then a new name will be required.

On a recent visit to Western Australia covering areas from Newman southwards to Kalgoorlie, I made observations on various populations of *Salsola* and collected specimens representing five distinct forms. For the purpose of this discussion, I have given these forms phrase names to distinguish the various herbarium collections deposited in AD and PERTH.

At Gwalia near Leonora, two forms occurred sympatrically on rocky slopes, *S. australis* subsp. **Compact** (R.J.Chinnock 10176) formed a rounded glabrous shrub to 0.8 m tall. *Salsola australis* subsp. **Compact** is a very common taxon and has been observed in various parts of Western Australia, Northern Territory and South Australia. The other form, *S. australis* subsp. **Strobilifera** (R.J.Chinnock 10177), was a low irregularly shaped glabrous shrub to 30 cm tall with well defined clusters of fruits forming 'cones' on short



Fig. 5. Forms of *Salsola australis* growing sympatrically on the Landor Road: *S. australis* subsp. **Compact** (left), subsp. **Glaucous** (right) and small plants of subsp. **Pubescent** (top centre).

lateral branches. This is the form that has commonly been referred to in the past as *S. kali* var. *strobilifera* (Fig. 3). It is very widespread in Australia, well-defined and probably requires specific status. Unlike *S. australis* subsp. **Compact** this form does not appear to become a tumbleweed.

At one site south of Mt Augustus on the Landor Road, a large population of *Salsola* occurred on disturbed areas adjacent to the road (Fig. 4). Three distinct forms were found growing sympatrically with no suggestion of hybridism (Fig. 5). One form, *S. australis* subsp. **Glaucous** (R.J.Chinnock 10206) formed an open shrub to 0.8 m tall. The branches and leaves were glabrous, bluish grey green and fruits were just starting to develop. The second was *S. australis* subsp. **Compact** (R.J.Chinnock 10205), the form found much further south at Gwalia. The third form *S. australis* subsp. **Pubescent** (R.J.Chinnock 10207) was a very compact low shrub to about 40 cm tall with densely pubescent branches, leaves and flowers. Unlike *S. australis* subsp. **Compact** which was fruiting, the two other forms at this location were flowering.

In the Newman area, another very distinct form occurs. *Salsola australis* subsp. **Lucid** (R.J.Chinnock 10212) is a dense rounded glabrous (or occasional scattered hairs on branch) shrub with shiny branches and leaves. It is commonly 40 to 80 cm tall but very large plants to 1.6 m tall and 3.2 m across were also observed (Fig. 6). It is characterised by having very shiny leaves and branches and in addition, the developing fruits, unlike other forms of *S. australis* observed, were coloured deep rose in the lower halves of wings (Fig. 7). The size dimensions of these larger plants greatly exceed those given by Wilson (1984) and, Borger & Scott (2009) for the species.

For the *Flora of South Australia*, I am following Borger & Scott (2009) in adopting the name *S. australis*.



Fig. 6. *Salsola australis* subsp. *Lucid*, near Newman, habit. — R.J.Chinnock 10212.

This species was first collected by Robert Brown at the beginning of the 19th century in the southern part of the continent so it is unlikely that at that time it had been introduced from elsewhere and likewise the diversity observed in populations within Australia would indicate that the species has had a considerably longer history in Australia than a mere few hundred years. The names *S. kali* and *S. tragus* are considered misapplied to Australian populations although the relationship between *S. tragus* and Australian populations still needs to be resolved.

There are at least 6 well-defined taxa represented in Western Australia, South Australia and Victoria of which at least three occur in South Australia namely, *S. australis* subsp. *Compact*, *S. australis* subsp. *Coastal* and *S. australis* subsp. *Strobilifera* — although I make no attempt to apply any infraspecific names. The forms of *S. australis* vary greatly and until there is a detailed Australia-wide molecular/taxonomic study of the complex undertaken I consider it foolhardy to try and apply any of the infraspecific names that have been previously proposed under the misapplied names like *S. kali* or *S. tragus*

Nomenclature

Salsola australis R.Br.

Prodr. 411 (1810). — *Kali australis* (R.Br.) Akhani & E.H.Roalson, Int. J. Pl. Sci. 168: 946 (2007) [based on *S. australis* R.Br. not "*Salsola kali* R.Br." as cited].

Salsola kali var. *pontica* Pall., Ill. Pl. 37 (1803), pro parte. — *Salsola tragus* subsp. *pontica* (Pall.) Rilke, Biblioth. Bot. 149: 133 (1999), pro parte.

?*Salsola macrophylla* R.Br., Prodr. 411 (1810).

Salsola brachypteris Moq., Chenop. Monogr. Enum 147 (1840). — *Salsola kali* var. *brachypteris* (Moq.) Benth., Fl. Austral. 5: 208 (1870).

Salsola kali var. *leptophylla* Benth., Fl. Austral. 5: 207 (1870).



Fig. 7. *Salsola australis* subsp. *Lucid*, fruiting branch showing the well-defined rose coloured band at the base of wings of the fruit. — R.J.Chinnock 10212

Salsola kali var. *strobilifera* Benth, Fl. Austral. 5: 207 (1870). — *S. australis* var. *strobilifera* (Benth.) Domin, Biblioth. Bot. 89: 628 (1921).

Salsola kali subsp. *austroafricana* Aellen, Mitt. Bot. Staatssamml. München 4: 27 (1961).

Salsola tragus subsp. *grandiflora* Rilke, Biblioth. Bot. 149: 135 (1999).

Salsola kali auct. non L: P.G.Wilson in A.S.George, Fl. Austral. 4: 314 (1984); P.G.Wilson in Jessop & Toelken, Fl. S. Austral. 1: 291 (1986); N.G.Walsh in N.G.Walsh & Entwisle, Fl. Victoria 3: 197 (1996); S.W.L.Jacobs in Harden, Fl. New South Wales 1: 238 (2000).

Salsola tragus auct. non L: Rilke, Biblioth. Bot. 149: 111 (1999), pro parte.

Conclusions

Salsola, widespread and common throughout most of Australia, is not likely to be confused with any other Chenopod genus. *Salsola australis* belongs to *Salsola* sect. *Kali* and is similar to other species of weedy tumbleweed in the section, like *S. kali* and *S. tragus*, widespread in Europe and Asia and introduced into many countries. As such the distinctiveness from these Eurasian species needs to be clarified. There are certainly very distinct forms included under the name *S. australis* but the relationships between these forms and at what level of classification they should be recognised must await until a comprehensive Australia-wide revision is undertaken.

Cited Specimens:

S. australis subsp. *Coastal*. R.J.Chinnock 10246, Pelican Point road, 0.6 km from T/O off Victoria Road, S.A., 3 Feb. 2010 (AD).

S. australis subsp. *Compact*. R.J.Chinnock 10176, Gwalia, just south of Leonora, northern slopes below Gwalia Museum, 11 June 2009 (AD, PERTH); R.J.Chinnock 10205, 4.3 km N of the Burringurrah Aboriginal Community on the Landor-Mt Augustus Road, 20 June 2009 (AD, PERTH).

***S. australis* subsp. *Glaucous*.** *R.J.Chinnock 10206*, 4.3 km N of the Burringurrah Aboriginal Community on the Landor-Mt Augustus Road, 20 June 2009 (AD, PERTH).

***S. australis* subsp. *Lucid*.** *R.J.Chinnock 10212*, Near Newman Racecourse, 2.4 km N of Kalgan Drive T/O on the Great Northern Highway, 22 June 2009 (AD, PERTH).

***S. australis* subsp. *Pubescent*.** *R.J.Chinnock 10207*, 4.3 km N of the Burringurrah Aboriginal Community on the Landor-Mt Augustus Road, 20 June 2009 (AD, PERTH).

***S. australis* subsp. *Strobilifera*.** *R.J.Chinnock 10020*, 3.2 km SW of the Munjini-Nanutarra Road junction with the Tom Price Road, 5 June 2006 (AD, PERTH); *R.J.Chinnock 10177*, Gwalia, just south of Leonora, northern slopes below Gwalia Museum, 11 June 2009 (AD, PERTH).

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CORRIGENDUM

Notes on *Hibbertia* (Dilleniaceae). 5.

H.R. Toelken

State Herbarium of South Australia, P.O. Box 2732, Kent Town, South Australia 5071

E-mail: hellmut.toelken@sa.gov.au

Abstract

Illegitimate names used for two species published by Toelken (2010) necessitate the new names *H. nemorosa* Toelken and *H. persquamata* Toelken to replace *H. heterotricha* Toelken and *H. complanata* Toelken, respectively. The new combination *H. persquamata* subsp. *ampliata* (Toelken)Toelken is added.

Keywords: Dilleniaceae, *Hibbertia*, nomenclature, taxonomy, new names.

Introduction

Two new names and a new combination are published here to replace names in the recent revision of *Hibbertia* §*Tomentosae* Benth. from tropical Australia (Toelken 2010). It was overlooked that the name *H. heterotricha* had previously been used for a New Caledonian species (Guillaumin 1920), and that the new combination *H. complanata* (R.Br. ex DC.) J.W.Horn (2009) just predated Toelken's homonym. The same numbering of the species is adhered to for quick reference.

3. *Hibbertia nemorosa* Toelken, *nom. nov.*

Basionym: *Hibbertia heterotricha* Toelken, J. Adelaide Bot. Gard. 23: 27 (2010), *nom. illeg.*, non *H. heterotricha* Bureau ex Guillaumin, Bull. Soc. Bot. France 67: 54 (1920). — **Typus:** Queensland, North Kennedy, Mt Spec Range, *C.H. Gittins* 493, v.1962 (holo.: BRI).

Etymology. The epithet 'nemorosa', Latin, 'growing in woods' refers to the often recorded habitat of the species as an understory shrub in forest.

34. *Hibbertia persquamata* Toelken, *nom. nov.*

Basionym: *Hibbertia complanata* Toelken, J. Adelaide Bot. Gard. 23: 81 (2010), *nom. illeg.*, non *H. complanata* (R.Br. ex DC.) J.W.Horn, Int. J. Pl. Sci. 170: 809 (2009). — **Typus:** Western Australia, Augustus Island, *P.A. Fryxell, L.A. Craven & J. McD. Stewart* 4698, 8.vi.1985 (holo.: CANB 377016; iso.: CANB 377017, PERTH).

Etymology. The epithet 'per-squamata', Latin, 'completely (densely) covered with scales' refers to the dense cover of scales, which distinguish this species from *H. echiifolia* R.Br. ex Benth. and *H. fractiflexa* Toelken.

34a. *Hibbertia persquamata* subsp. *persquamata*

34b. *Hibbertia persquamata* subsp. *ampliata* (Toelken) Toelken, *comb. nov.*

Basionym: *Hibbertia complanata* subsp. *ampliata* Toelken, J. Adelaide Bot. Gard. 23: 82 (2010). — **Typus:** Western Australia, Lushington Brook, Prince Regent River, *C.A. Gardner* 9572, 3.vii.1950 (holo.: PERTH 3029905, right hand specimen with flower; iso.: PERTH 3029905 left hand branches and dupl. sheet).

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